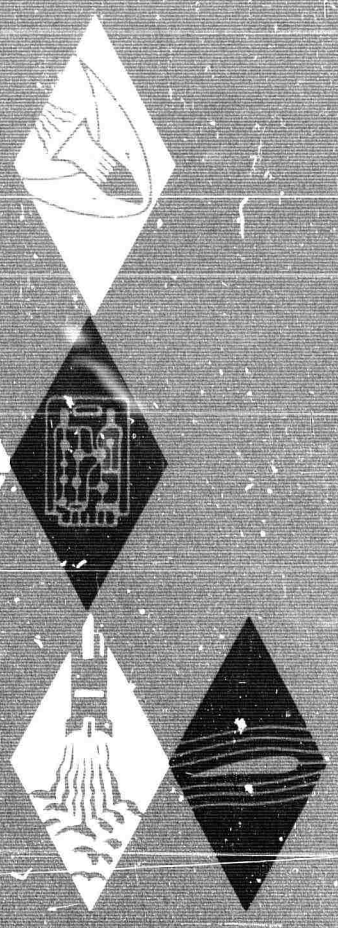


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TECHNICAL REPORT NO. 501

A FINITE DIFFERENCE METHOD SOLUTION
OF NON-SIMILAR, EQUILIBRIUM
AND NON-EQUILIBRIUM AIR,
BOUNDARY LAYER EQUATIONS
WITH LAMINAR AND TURBULENT
VISCOSITY MODELS

PART II: COMPUTER PROGRAM
AND SUPPLEMENT
(FINAL REPORT)

By H. E. Gould
L. S. Galowin

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Prepared for
Advanced Research Projects Agency
Washington 25, D. C.

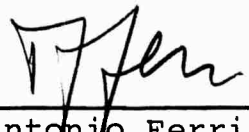
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SUMMARY

This report describes a program for the numerical solution by an explicit finite difference technique of the momentum, species conservation, and energy equations for an equilibrium or chemically reacting air boundary layer. Laminar and several turbulent viscosity models can be applied through the thickness of the boundary layer. Seven air species are included: O_2 , O , N_2 , N , NO , NO^+ and e^- .

Laminar and turbulent effects in any of the equations can be selectively controlled by input indicators. The various viscosity models can be applied to the entire thickness of the boundary layer or the boundary layer can be divided into two segments and different viscosity models applied to each segment. Provision has also been made for boundary layer swallowing of new inviscid streamlines. Properties along the inviscid streamline are computed to establish the varying streamwise outer edge conditions.

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I. INTRODUCTION

This program is written in FORTRAN II language for the IBM 7090-4. It solves the non-equilibrium and equilibrium air boundary layer conservation equations for momentum, energy and species mass fractions. These parabolic partial differential equations are solved in the domain defined by the body surface and the inviscid edge of the boundary layer. The technique of solution is an explicit finite difference method. The boundary conditions at the body are specified as input data but those at the inviscid outer edge are not known a priori and are therefore computed as the calculation progresses. Edge conditions are determined from the solution of ordinary differential equations

which yield the velocity and species along an approximate inviscid streamline from the shock to the body station of interest. Initial conditions to start the problem require the distributions of the dependent variables of velocity, total enthalpy, and species mass fractions.

A number of significant capabilities are provided by the program. The multicomponent air species considered are O_2 , O , N_2 , N , NO , NO^+ and e^- . Laminar and several turbulent viscosity representations may be optionally selected for the diffusional transport terms applied to any of the partial differential equations. The boundary layer thickness can be divided into two segments and different viscosity models applied to each of the segments. Various two-dimensional or axisymmetric body geometrical configurations are possible. Similarly, shock shapes consisting of conical and parabolic segments are acceptable. Input tolerances upon the slope at the outer edge of the enthalpy, velocity or species profiles govern the boundary layer swallowing which results from the growth of the viscous layer into the inviscid flow.

The program described herein is based upon the analysis reported in Part I. The engineering definitions and the preparation of input data for application of the program to given boundary

layer problems are discussed in the Part III manual.

Typical hypersonic reentry body configurations have been investigated. Computer time required for their solution ranges from 3/4 to 4 hours, depending on body length, altitude, free stream velocities and mode of computation.

II. BOUNDARY LAYER EQUATIONS

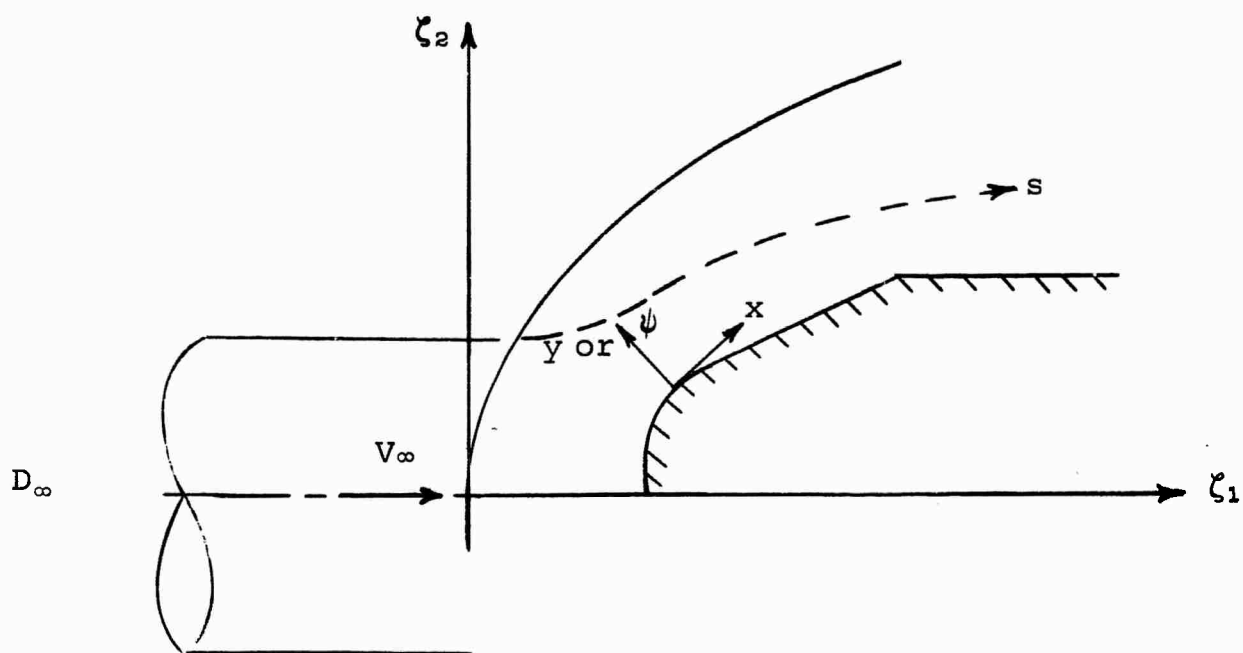
In this section the explicit finite difference method solution of the boundary layer conservation equations is described.

A. Coordinate Systems

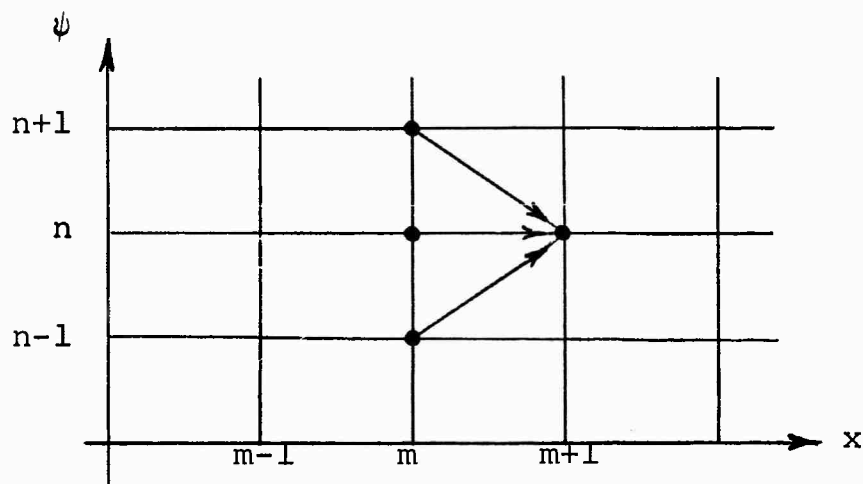
The program continuously calculates in four different coordinate systems. Thus for the permissible body and shock geometry configurations, the following systems shown in the sketch below are defined:

1. Overall - a basic reference system designated as ζ_1, ζ_2 . The units of these coordinates are feet.
2. Physical - an x-y system where x, in feet, is along the body and y, in feet, is normal to the body.
3. Body and von Mises stream function - an x- Ψ system in which the finite difference solutions will be solved, where x, in feet, is along the body and Ψ is the transformed normal coordinate and represents the stream function defined by $\Psi = \int_0^y \rho u r^\epsilon dy$. For $\epsilon = 1$, Ψ is in slugs/sec; for $\epsilon = 0$, Ψ is in slugs/ft-secs. The sketch below shows the grid in the x- Ψ plane with the paths of the numerical step indicated.

4. Inviscid streamline - a fourth system is a one-dimensional coordinate, s , along the (approximate inviscid) streamline. The origin of this coordinate system is the shock streamtube intersection point.



Coordinate Systems for a Blunt Body



Finite Difference Grid

B. Momentum Equation

1. Analytic form

$$\frac{\partial u}{\partial x} = - \frac{1}{\rho u} \frac{dp}{dx} + r^\epsilon \frac{\partial \tau}{\partial \Psi}$$

$$\tau = \mu \frac{\partial u}{\partial \Psi} \rho u r^\epsilon$$

2. Finite difference form

$$u_{m+1,n} = u_{m,n} - \frac{\Delta x}{\rho_{m,n} u_{m,n}} \left(\frac{dp}{dx} \right)_m + \frac{\Delta x}{\Delta \Psi} r_m^\epsilon \left(\tau_{m,n+1/2} - \tau_{m,n-1/2} \right)$$

Note: Near the wall a series solution has been assumed since $u \rightarrow 0$. The expressions used are:

$$u = a_1 \Psi^{1/2} + b_1 \Psi$$

$$c_i = c_{i_w} + a_{i_2} \Psi^{1/2} + b_{i_2} \Psi$$

$$H = H_w + a_3 \Psi^{1/2} + b_3 \Psi$$

$$\rho u = a_4 \Psi^{1/2} + b_4 \Psi$$

Using the variables evaluated at $\Delta \Psi$ and $2\Delta \Psi$, the a_n 's and b_n 's are determined. Thus from the series solution the values at $\frac{\Delta \Psi}{2}$ required in the

finite difference solution of the momentum, species and energy equations are then evaluated.

3. The difference in shear stress

$$\Delta\tau = \left[\frac{(\rho u r^\epsilon)_{m,n+1} + (\rho u r^\epsilon)_{m,n}}{2} \right] \left[\frac{A_1^L (\mu_{m,n+1}^L + \mu_{m,n}^L)}{2} + A_1^T \frac{T_{m,n+1/2}}{\mu_{m,n+1/2}} \right] \left[\frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right]$$

$$- \left[\frac{(\rho u r^\epsilon)_{m,n} + (\rho u r^\epsilon)_{m,n-1}}{2} \right] \left[\frac{A_1^L (\mu_{m,n}^L + \mu_{m,n-1}^L)}{2} + A_1^T \frac{T_{m,n-1/2}}{\mu_{m,n-1/2}} \right] \left[\frac{u_{m,n} - u_{m,n-1}}{\Delta\psi} \right]$$

4. Viscosity models

a. Laminar $\mu_{m,n}^L = \frac{3.04566 \times 10^{-8} T_{m,n}^{1.5}}{110.333 + T_{m,n}}$

b. Turbulent $\frac{-T}{\mu} = B_1^T \mu^{T1} + B_2^T \mu^{T2} + B_3^T \mu^{T3} + B_4^T \mu^{T4}$
 $+ B_5^T \mu^{T5} + B_6^T \mu^{T6} + B_7^T \mu^{T7}$ where the B's are input coefficients and the μ^{Ti} are defined as follows:

i. Law of the wall - dimensional coordinate, y

$$\mu_{m,n+1/2}^{T1} = \left\{ y_{m,n} + \Delta\psi \left[\frac{.375}{(\rho_{ur}^{\epsilon})_{m,n}} + \frac{.125}{(\rho_{ur}^{\epsilon})_{m,n+1}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\}$$

$$\left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n+1} + (\rho_{ur}^{\epsilon})_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right|$$

$$\mu_{m,n-1/2}^{T1} = \left\{ y_{m,n} - \Delta\psi \left[\frac{.125}{(\rho_{ur}^{\epsilon})_{m,n-1}} + \frac{.375}{(\rho_{ur}^{\epsilon})_{m,n}} \right] \right\}^2 (FK)^2 \left\{ \frac{\rho_{m,n} + \rho_{m,n+1}}{2} \right\}$$

$$\left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n} + (\rho_{ur}^{\epsilon})_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\psi} \right|$$

ii. Law of the wake - dimensional coordinate, y_e .

$$\mu_{m,n+1/2}^{T2} = \left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\} \left\{ \frac{K_{m,n+1} + K_{m,n}}{2} \right\} (Y_e^u)_m$$

$$\mu_{m,n-1/2}^{T2} = \left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{K_{m,n} + K_{m,n-1}}{2} \right\} (Y_e^u)_m$$

where $K(N)$ is an input function of ψ

$$K(N) = a + b\psi + c\psi^2$$

iii. Laminar contribution

$$\mu_{m,n+1/2}^{T3} = 1/2 \{ \mu_{m,n}^L + \mu_{m,n+1}^L \}$$

$$\mu_{m,n-1/2}^{T3} = 1/2 \{ \mu_{m,n}^L + \mu_{m,n-1}^L \}$$

iv. Eddy viscosity fit - dimensional coordinate, y

$$\mu_{m,n+1/2}^{T4} = \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n} + \Delta\psi \left(\frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} + \frac{.125}{(\rho_{ur}^\epsilon)_{m,n+1}} \right)}{(Y_e)_m} \right)^2 \right. \right. \\ \left. \left. - .06 \left(1 - \frac{Y_{m,n} + \Delta\psi \left(\frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} + \frac{.125}{(\rho_{ur}^\epsilon)_{m,n+1}} \right)}{(Y_e)_m} \right)^4 \right] \right\}^2 \\ \left\{ \frac{\rho_{m,n} + \rho_{m,n+1}}{2} \right\} \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\psi} \right|$$

$$\mu_{m,n-1/2}^{T4} = \left\{ (Y_e)_m \left[.14 - .08 \left(1 - \frac{Y_{m,n}^{-\Delta\Psi} \left(\frac{.125}{(\rho_{ur}^\epsilon)_{m,n-1}} + \frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} \right)}{(Y_e)_m} \right) \right]^2 - .06 \left(1 - \frac{Y_{m,n}^{-\Delta\Psi} \left(\frac{.125}{(\rho_{ur}^\epsilon)_{m,n-1}} + \frac{.375}{(\rho_{ur}^\epsilon)_{m,n}} \right)}{(Y_e)_m} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

v. Law of the wall - streamline coordinate, Ψ

$$\mu_{m,n+1/2}^{T5} = \left[\left(\Psi_n + \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^\epsilon} \right)_m \right]^2 \left[\frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right] \left[\frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right]$$

$$\left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi} \right|$$

$$\mu_{m,n-1/2}^{T5} = \left[\left(\Psi_n - \frac{\Delta\Psi}{2} \right) \left(\frac{FK}{\rho_e u_e r^\epsilon} \right)_m \right]^2 \left[\frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right] \left[\frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n-1}}{2} \right]$$

$$\left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

vi. Law of the wake - streamline coordinate, Ψ_e

$$\mu_{m,n+1/2}^{T6} = \left(\frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right) \left(\frac{K_{n+1} + K_n}{2} \right) \frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

$$\mu_{m,n-1/2}^{T6} = \left(\frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right) \left(\frac{K_n + K_{n-1}}{2} \right) \frac{\Psi_e}{(\rho_e r^\epsilon)_m}$$

vii. Eddy viscosity fit - streamline coordinate, Ψ

$$\mu_{m,n+1/2}^{T7} = \left\{ \frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m} \left[.14 - .08 \left(1 - \frac{\Psi_n + \frac{\Delta\Psi}{2}}{\Psi_e} \right)^2 - .06 \left(1 - \frac{\Psi_n + \frac{\Delta\Psi}{2}}{\Psi_e} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n+1} + \rho_{m,n}}{2} \right\} \left\{ \frac{(\rho u r^\epsilon)_{m,n+1} + (\rho u r^\epsilon)_{m,n}}{2} \right\} \left| \frac{u_{m,n+1} - u_{m,n}}{\Delta\Psi} \right|$$

$$\mu_{m,n-1/2}^{T7} = \left\{ \frac{\Psi_e}{(\rho_e u_e r^\epsilon)_m} \left[.14 - .08 \left(1 - \frac{\Psi_n - \frac{\Delta\Psi}{2}}{\Psi_e} \right)^2 - .06 \left(1 - \frac{\Psi_n - \frac{\Delta\Psi}{2}}{\Psi_e} \right)^4 \right] \right\}^2$$

$$\left\{ \frac{\rho_{m,n} + \rho_{m,n-1}}{2} \right\} \left\{ \frac{(\rho u r^\epsilon)_{m,n} + (\rho u r^\epsilon)_{m,n-1}}{2} \right\} \left| \frac{u_{m,n} - u_{m,n-1}}{\Delta\Psi} \right|$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_u is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_u . If $\epsilon_u = 0$, the streamline test is not made. If ϵ_u is set as any positive number (used as the tolerance), the test

$$\left| \frac{u_{m+1}(L+1) - u_{m+1}(L-1)}{u_{m+1}(L+1)} \right| \leq \epsilon_u$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $u_{m+1}(L-J) = \frac{u_m(L-J)}{u_m(L-1)} u_{m+1}(L+2)$, for $J = 2, 3, 4$, and $u_{m+1}(L-1) = u_{m+1}(L+2)$.

6. Boundary conditions

- a. Initial distributions - an input velocity profile vs. physical coordinates.
- b. Inner value at the wall - $u = 0$.
- c. Outer edge - velocity at the outer edge is obtained from the finite difference equation of "B" or the inviscid streamline solution of $u \frac{du}{ds} = - \frac{1}{\rho} \frac{dp}{ds}$ accordingly as the momentum, species

or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5, II.D.5 for formulation of tests).

- d. Inviscid streamlines - two inviscid streamlines external to the boundary layer which represent the locally uniform (assumed) external flow are always computed.

C. Species Equation

1. Analytic form

$$\frac{\partial c_i}{\partial x} = \frac{\dot{w}_i A_2}{\rho u} + r^\epsilon \frac{\partial \phi}{\partial \Psi}, \quad i = 1, 2, \dots, 7$$

2. Finite difference form

$$(c_i)_{m+1,n} = (c_i)_{m,n} + \frac{\Delta x (\dot{w}_i)_{m,n} A_2}{(\rho u)_{m,n}} + \frac{\Delta x}{\Delta \Psi} r_{m,n}^\epsilon \left[\phi_{m,n+1/2} - \phi_{m,n-1/2} \right]$$

See Section II.B.2 for note regarding solution near the wall.

3. The species diffusion terms are given by:

$$\begin{aligned}
 \Delta \mathcal{G} = & \frac{1}{2} \left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n+1} + (\rho_{ur}^{\epsilon})_{m,n}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n+1} + \left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n} \right] \right. \\
 & + A_3^L \mu_{m,n+1}^T \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n+1} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} \right] \left. \left\{ \frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right\} \right. \\
 & - \frac{1}{2} \left\{ \frac{(\rho_{ur}^{\epsilon})_{m,n} + (\rho_{ur}^{\epsilon})_{m,n-1}}{2} \right\} \left\{ A_3^L \left[\left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n} + \left(\frac{\mu_{D_{ki}}^L}{S_c^L D^L} \right)_{m,n-1} \right] \right. \\
 & + A_3^L \mu_{m,n-1}^T \left[\left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n} + \left(\frac{1}{S_c^T} \frac{D_{ki}^T}{D^T} \right)_{m,n-1} \right] \left. \left\{ \frac{(C_i)_{m,n} - (C_i)_{m,n-1}}{\Delta \Psi} \right\} \right.
 \end{aligned}$$

4. Chemistry production terms

a. Formulation

$$\dot{w}_i(\Psi, x) = \dot{w}_i(T, \rho, C_i), \quad i = 1, 2, \dots, 7$$

$$\dot{w}_{O_2} = \frac{\rho}{L} \left[-A + \frac{M_{O_2}}{M_{NO}} D \right]$$

$$\dot{w}_O = \frac{\rho}{L} \left[A + \frac{M_O}{M_{NO}} (C-D-E) - \frac{M_O}{M_{NO^+}} F \right]$$

$$\dot{w}_{N_2} = -\frac{\rho}{L} \left[B + \frac{M_{N_2}}{M_{NO}} E \right]$$

$$\dot{w}_N = \frac{\rho}{L} \left[B + \frac{M_N}{M_{NO}} (C+D+E) - \frac{M_N}{M_{NO^+}} F \right]$$

$$\dot{w}_{NO} = \frac{\rho}{L} \left[-C-D+E-K \right]$$

$$\dot{w}_{NO^+} = \frac{\rho}{L} \left[F+K \right]$$

$$\dot{w}_{e^-} = \frac{\rho}{L} \frac{M_e}{M_{NO^+}} \left[F+K \right]$$

where

$$A = \frac{2L}{M_O} \left[\sum_i \frac{C_i}{M_i} K_{ra}^i \right] \rho \left[\rho_{do} C_{O_2} e^{D_{O_2}/KT} - \rho C_O^2 \right] 9.6573302 \times 10^{25}$$

$$B = \frac{2L}{M_N} \left[\sum_i \frac{C_i}{M_i} K_{rb}^i \right] \rho \left[\rho_{dN} C_{N2} e^{-D_{N2}/KT} - \rho C_N^2 \right] 9.6573302 \times 10^{25}$$

$$C = \frac{LM_{NO}}{M_N M_O} \left[\sum_i \frac{C_i}{M_i} \right] K_{rc} \rho \left[\rho_{dNO} C_{NO} e^{-D_{NO}/KT} - \rho C_N C_O \right] 9.6573302 \times 10^{25}$$

$$D = \frac{LM_{NO}}{M_N M_{O2}} K_{rd} \rho \left[\sigma C_{NO} C_O e^{-\frac{D_{NO} - D_{O2}}{KT}} - C_{O2} C_N \right] 3.1076201 \times 10^{23}$$

$$E = \frac{LK_{re}}{M_N} \rho \left[\gamma C_{N2} C_O e^{-\frac{D_{N2} - D_{NO}}{KT}} - C_{NO} C_N \right] 3.1076201 \times 10^{23}$$

$$F = \frac{LK_{rf}}{M_e} \rho \left[\frac{1}{K} C_O C_N e^{-\frac{I_{NO} - D_{NO}}{KT}} - (C_{NO^+}) C_e \right] 3.1076201 \times 10^{23}$$

$$K = \frac{L}{M_e} \left[\sum_i \frac{C_i}{M_i} K_{rk}^i \right] \rho \left[\rho_{de} C_{NO} e^{-I_{NO}/KT} - \rho (C_{NO^+}) C_e \right] 9.6573302 \times 10^{25}$$

Set

$$ETT \ 228 = 5 + 3 e^{-228/T} + e^{-327/T}$$

$$ET \ 178 = 1 + e^{-178/T}$$

$$ET\ 2274 = 1 - e^{-2274/T}$$

$$ET\ 2740 = 1 - e^{-2740/T}$$

$$ET\ 3395 = 1 - e^{-3395/T}$$

$$ET\ 1130 = 3 + 2 e^{-11300/T}$$

Then

$$\sigma_{dO} = \frac{M_O}{2\eta h_p^3} (\pi m_O KT)^{3/2} \left(\frac{4.161}{T} \right) (ET\ 2274) \left(\frac{(ETT\ 228)^2}{ET\ 1130} \right) 3.87871 \times 10^{-11}$$

$$\sigma_{dN} = \frac{8M_N}{\eta h_p^3} (\pi m_N KT)^{3/2} \left(\frac{5.789}{T} \right) (ET\ 3395) 3.87871 \times 10^{-11}$$

$$\sigma_{dNO} = \frac{M_O}{\eta h_p^3} (2\pi m_O KT)^{3/2} \left(\frac{M_N}{M_{NO}} \right)^{5/2} \left(\frac{4.906}{T} \right) (ET\ 2740) \left(\frac{ETT\ 228}{ET\ 178} \right) 3.87871 \times 10^{-11}$$

$$\sigma = \left(\frac{M_{O2} M_N}{M_{NO} M_O} \right)^{5/2} \left(\frac{4.906}{4.161} \right) \left(\frac{ET\ 2740}{ET\ 2274} \right) \left(\frac{ET\ 1130}{ETT\ 228\ ET\ 178} \right)$$

$$\gamma = 16 \left(\frac{M_{NO} M_N}{M_{N2} M_O} \right)^{5/2} \left(\frac{5.789}{4.906} \right) \left(\frac{ET\ 3395}{ET\ 2740} \right) \left(\frac{ET\ 178}{ETT\ 228} \right)$$

$$\bar{K} = \left(\frac{M_{NO^+} \cdot M_e}{M_N M_O} \right)^{5/2} \left(\frac{T}{5.789} \right) \left(\frac{1}{ET \ 3395 \ ETT \ 228} \right)$$

$$\rho_{de} = \frac{M_e (2\pi m_e KT)^{3/2}}{\eta_p^3} (.4237) \left(\frac{ET \ 2740}{ET \ 3395} \right) \frac{2}{ET \ 178} 3.87871 \times 10^{-11}$$

b. Input $A_2 = 1$ for reacting system

= 0 for frozen system; bypass all \dot{w}_i

= - 1 for equilibrium system.

= 10 for reacting system with equilibrium at the wall

5. Equilibrium mass action laws

As indicated in II.C.4.b, an input of -1 for A_2 , activates the logic for obtaining the species from the following equilibrium relationships:

$$c_{m+1}(O_2) = \frac{908.19 \ T^{5/2} \left(\frac{5}{3} e^{-\frac{11391}{T}} + \frac{1}{3} e^{-\frac{18985}{T}} \right) \bar{A}^2 (2.773 \times 10^{-15})}{\rho \left(1 - e^{-\frac{2274}{T}} \right)}$$

$$c_{m+1}(O) = \frac{2237 T^{3/2} \left(1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}} \right) e^{-\frac{29501}{T}} \bar{A} (1.386 \times 10^{-9})}{\rho}$$

$$c_{m+1}(N_2) = \frac{178.39 T^{5/2} B^2 (2.428 \times 10^{-15})}{\rho \left(1 - e^{-\frac{3395}{T}} \right)}$$

$$c_{m+1}(N) = \frac{1462 T^{3/2} (3.5) \left(e^{-\frac{27698}{T}} + \frac{3}{2} e^{-\frac{41520}{T}} \right) e^{-\frac{56544}{T}} \bar{B} (1.214 \times 10^{-9})}{\rho}$$

$$c_{m+1}(NO) = \frac{934.14 T^{5/2} \left(1 - e^{-\frac{178}{T}} \right) e^{-\frac{11063}{T}} \bar{AB} (2.6 \times 10^{-15})}{\rho \left(1 - e^{-\frac{2740}{T}} \right)}$$

$$c_{m+1}(NO^+) = 233.9 \sqrt{\frac{.1597 \times 10^{-11} T e^{-\frac{32125}{T}} c_{m+1}(O) c_{m+1}(N)}{\left(1 - e^{-\frac{3395}{T}} \right) \left(1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}} \right)}}$$

$$c_{m+1}(e^-) = \frac{1}{(233.9)^2} c_{m+1}(NO^+)$$

\bar{A} and \bar{B} are obtained from an iteration procedure which is satisfied when two successive values of \bar{B} agree to within $\frac{1}{1000}$ %.

The iteration procedure is initiated with $\bar{B} = 0$ and then the following calculations take place in the sequence shown:

$$BT = \frac{\left(2237 T^{3/2} B_4 e^{-\frac{29501}{T}} \right) \bar{B} \left(934.14 T^{5/2} E_4 e^{-\frac{11063}{T}} \right) 10^{-18}}{E_3}$$

$$AC = \frac{(908.19 T^{5/2}) B_1 \rho (1338.7 \times 10^{-12})}{E_1}$$

$$\bar{A} = \frac{\left(-BT \sqrt{(BT)^2 + AC} E_1 \right)}{(908.19 T^{5/2} E_1) (4 \times 10^{-12})}$$

$$BT = \frac{\left(1461.9 T^{3/2} E_5 e^{-\frac{56544}{T}} \right) \bar{A} \left(934.14 T^{5/2} E_4 e^{-\frac{11063}{T}} \right) 10^{-18}}{E_3}$$

$$AC = \frac{(178.39 T^{5/2}) \rho (5060.8 \times 10^{-12})}{E_2}$$

$$\bar{B} = \frac{\left(-BT + \sqrt{(BT)^2 + AC} \right) E_2}{(178.39 T^{5/2}) (4 \times 10^{-12})}$$

where

$$B_1 = \frac{5}{3} e^{-\frac{11390}{T}} + \frac{1}{3} e^{-\frac{18984}{T}}$$

$$B_4 = 1.6 e^{-\frac{228}{T}} + .2 e^{-\frac{326}{T}}$$

$$B_5 = 3.5 e^{-\frac{27698}{T}} + 1.5 e^{-\frac{41520}{T}}$$

$$E_1 = 1 - e^{-\frac{2274}{T}}$$

$$E_2 = 1 - e^{-\frac{3395}{T}}$$

$$E_3 = 1 - e^{-\frac{2740}{T}}$$

$$E_4 = 1 - e^{-\frac{178}{T}}$$

6. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_c is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_c . If $\epsilon_c = 0$, the streamline test is made. If ϵ_c is set as any positive number (used as the tolerance) the test

$$\left| \frac{c_{m+1,i}(L+1) - c_{m+1,i}(L-1)}{c_{m+1,i}(L+1)} \right| \leq \epsilon_c \quad i=1, \dots, 7$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over. When the incremented expansion of the Ψ grid is called for then set $c_{m+1}(L-J)$

$$= \frac{c_m(L-J)}{c_m(L-1)} c_{m+1}(L+2), \text{ for } J = 2, 3, 4 \text{ and}$$

$$c_{m+1}(L-1) = c_{m+1}(L+2).$$

7. Boundary conditions

- a. Initial - $c_i(y)$ profiles are input for all species except N_2 and e^- , which are computed from:

$$c_{e^-}(N) = \frac{M_{e^-}}{M_{NO^+}} c(NO^+)$$

$$c_{N_2}(N) = 1 - \sum c_i \quad i \neq N_2$$

- b. Wall - $c_{m+1}(I) = C_1(I) + C_2(I) \frac{x}{Rn} + C_3(I) \left(\frac{x}{Rn}\right)^2$
 $+ C_4(I) \left(\frac{x}{Rn}\right)^3 + C_5(I) \left(\frac{x}{Rn}\right)^4$ where the C_1 through C_5 are input for each specie except e^- .

- c. Outer edge - Species at the outer edge are obtained from the finite difference equation in Subsection II.C.2. or the inviscid solution of $u \frac{dc_i}{ds} = \frac{\dot{w}_i}{\rho}$ accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5, II.C.5., II.D.5. for formulation of tests).
- d. Along the two external inviscid streamlines the species are obtained from the inviscid equation.

D. Energy Equation

1. Analytic form

$$\frac{\partial H}{\partial x} = r^\epsilon \frac{\partial}{\partial \Psi} (\mathcal{E}^H + \mathcal{E}^C)$$

2. Finite difference form

$$\begin{aligned} H_{m+1,n} = H_{m,n} + r_m^\epsilon \frac{\Delta x}{\Delta \Psi} (\mathcal{E}_{m,n+1/2}^H - \mathcal{E}_{m,n-1/2}^H) \\ + r_m^\epsilon \frac{\Delta x}{\Delta \Psi} (\mathcal{E}_{m,n+1/2}^C - \mathcal{E}_{m,n-1/2}^C) \end{aligned}$$

See Section II.B.2. for note regarding solution near the wall.

3. The difference of enthalpy-kinetic energy terms \mathcal{E}^H is given by:

$$\underline{N = 2}$$

$$UAVG1 = \frac{r^\epsilon}{\Delta\Psi} \left[\rho_{\frac{1}{2}} u_{\frac{1}{2}}^2 \left(\frac{du}{d\Psi} \right)_{\frac{1}{2}} + \rho_2 u_2^2 \frac{(u_2 + u_3)}{2} - u_{\frac{1}{2}} \right]$$

$$UAVG2 = \frac{r^\epsilon}{2\Delta\Psi} \left[(\rho_3 u_3^2 + \rho_2 u_2^2) (u_3 - u_2) + \rho_2 u_2^2 (u_2 + u_3 - 2u_{\frac{1}{2}}) \right]$$

$$SUMHL = 2 \sum_i h_{i\frac{1}{2}} \left(\frac{D_{ki}}{D_2^L} + \frac{D_{ki}}{D_1^L} \right) \left(\frac{dC_i}{d\Psi} \right)_{\frac{1}{2}}$$

$$SUMHT = 2 \sum_i h_{i\frac{1}{2}} \left(\frac{D_{ki}}{D_2^T} + \frac{D_{ki}}{D_1^T} \right) \left(\frac{dC_i}{d\Psi} \right)_{\frac{1}{2}}$$

$$RURN = 2(\rho u)_{\frac{1}{2}} r^\epsilon$$

$$\begin{aligned} PARTH2 = \frac{1}{4} (RURN) & \left[A_4^L \mu_{\frac{1}{2}}^L \left(\frac{1}{P_{r_2}^L} + \frac{1}{P_{r_1}^L} \right) + 2A_4^T \left(\frac{\mu_{3/2}^T}{P_{r_1}^T} \right) \right] \left(\frac{dH}{d\Psi} \right)_{\frac{1}{2}} \\ & + \left[A_4^L (\mu_2^L + \mu_{\frac{1}{2}}^L) \left(1 - \frac{1}{P_{r_2}^L} \right) \frac{A_4^T}{2} \mu_{3/2}^T \left(1 - \frac{1}{P_{r_2}^T} \right) \right] UAVG1 \end{aligned}$$

$$\begin{aligned} PARTC2 = \frac{1}{8} \left[2 - \frac{1}{L_{e_2}^L} - \frac{1}{L_{e_1}^L} \right] & \left[\frac{1}{S_{c_2}^L} + \frac{1}{S_{c_1}^L} \right] (RURN) \frac{A_5^L}{4} \mu_{\frac{1}{2}}^L (SUMHL) + \\ \frac{1}{8} \left[2 - \frac{1}{L_{e_2}^T} - \frac{1}{L_{e_1}^T} \right] & \left[\frac{1}{S_{c_2}^T} + \frac{1}{S_{c_1}^T} \right] (RURN) \frac{A_3^T}{4} \mu_{\frac{1}{2}}^T (SUMHT) \end{aligned}$$

$$\underline{N > 2}$$

$$UAVG1 = \frac{r^\epsilon}{2\Delta\Psi} \left[\rho_n u_n^2 (u_{n+1} - u_{n-1}) + (\rho_n u_n^2 + \rho_{n-1} u_{n-1}^2) (u_n - u_{n-1}) \right]$$

$$UAVG2 = \frac{r^\epsilon}{2\Delta\Psi} \left[\rho_n u_n^2 (u_{n+1} - u_{n-1}) + (\rho_{n+1} u_{n+1}^2 + \rho_n u_n^2) (u_{n+1} - u_n) \right]$$

$$SUMHL = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^L} + \frac{D_{ki}}{D_{n-1}^L} \right) \left(\frac{dc_i}{d\Psi} \right)$$

$$SUMHT = \sum_i (h_{i_n} + h_{i_{n-1}}) \left(\frac{D_{ki}}{D_n^T} + \frac{D_{ki}}{D_{n-1}^T} \right) \left(\frac{dc_i}{d\Psi} \right)$$

$$RURN = r^\epsilon (\rho_n u_n + \rho_{n-1} u_{n-1})$$

$$PARTH2 = \frac{1}{4} (RURN) \left[A_4^L \left(\frac{\mu_n^L}{p_{r_n}^L} + \frac{\mu_{n-1}^L}{p_{r_{n-1}}^L} \right) + A_4^T \left(\frac{\mu_{n-1/2}^T}{p_{r_{n-1}}^T} \right) \right] \frac{dH}{d\Psi} +$$

$$\left[\frac{A_4^L}{4} (\mu_{n-1}^L) \left(1 - \frac{1}{p_{r_{n-1}}^L} \right) + 3\mu_n^L \left(1 - \frac{1}{p_{r_n}^L} \right) + A_4^T \mu_{n-1/2}^T \right]$$

$$\left(1 - \frac{1}{p_{r_n}^T} \right) \right] UAVG1$$

$$\text{PARTC2} = \frac{1}{16} \left(2 - \frac{1}{L_{e_n}^L} - \frac{1}{L_{e_{n-1}}^L} \right) \left(\frac{1}{S_{c_n}^L} + \frac{1}{S_{c_{n-1}}^L} \right) (\text{RURN})$$

$$\frac{A_8^L}{4} (\mu_n^L + \mu_{n-1}^L) (\text{SUMHL}) + \frac{1}{8} \left(2 - \frac{1}{L_{e_n}^T} - \frac{1}{L_{e_{n-1}}^T} \right)$$

$$\left(\frac{1}{S_{c_n}^T} + \frac{1}{S_{c_{n-1}}^T} \right) (\text{RURN}) \frac{A_8^T}{4} \mu_{n-1/2}^T (\text{SUMHT})$$

$$\Delta \rho^H = \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n+1} + (\rho_{ur}^\epsilon)_{m,n}}{2} \right\} \left\{ A_4^L \left[\frac{\left(\frac{\mu^L}{P_r^L} \right)_{m,n+1} + \left(\frac{\mu^L}{P_r^L} \right)_{m,n}}{2} \right] + 2A_4^T \left(\frac{\mu^T}{P_r^T} \right)_{m,n+1/2} \right\}$$

$$\left\{ \frac{H_{m,n+1} - H_{m,n}}{\Delta \Psi} \right\} + \left\{ \frac{(\rho_{ur}^\epsilon)_{m,n} + (\rho_{ur}^\epsilon)_{m,n+1}}{2} \right\} \left\{ A_4^L \left[\frac{\mu_{n+1}^L \left(1 - \frac{1}{P_r^L} \right) + 3\mu_n^L \left(1 - \frac{1}{P_r^L} \right)}{2} \right] \right\}$$

$$+ A_4^L \left[\mu_{n+1/2}^T \left(1 - \frac{1}{P_r^T} \right) \right] \left\{ \text{UAVG2} - \text{PARTH2} \right\}$$

4. The energy transport due to species gradients \mathcal{C}^c is given by:

$$\Delta \mathcal{C}^c = \frac{1}{16} \left[\left(1 - \frac{1}{L_e^L} \right)_{m,n+1} + \left(1 - \frac{1}{L_e^L} \right)_{m,n} \right] \left[\left(\frac{1}{S_c^L} \right)_{m,n+1} + \left(\frac{1}{S_c^L} \right)_{m,n} \right]$$

$$\left[(\rho_{ur} \epsilon)_{m,n+1} + (\rho_{ur} \epsilon)_{m,n} \right] \left[A_s^L (\mu_{m,n+1}^L + \mu_{m,n}^L) \right] \cdot \left[\frac{1}{4} \sum_i (h_{i,m,n+1} + h_{i,m,n}) \right]$$

$$\left[\left(\frac{D_{ki}^L}{D^L} \right)_{m,n+1} + \left(\frac{D_{ki}^L}{D^L} \right)_{m,n} \right] \left[\frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right] + \frac{1}{8} \left[\left(1 - \frac{1}{L_e^T} \right)_{m,n+1} + \left(1 - \frac{1}{L_e^T} \right)_{m,n} \right]$$

$$\left[\left(\frac{1}{S_c^T} \right)_{m,n+1} + \left(\frac{1}{S_c^T} \right)_{m,n} \right] \left[(\rho_{ur} \epsilon)_{m,n+1} + (\rho_{ur} \epsilon)_{m,n} \right] \left[A_s^{T-T} \mu_{m,n+1/2}^T \right]$$

$$\frac{1}{4} \sum_i \left[(h_{i,m,n+1} + h_{i,m,n}) \right] \left[\left(\frac{D_{ki}^T}{D^T} \right)_{m,n+1} + \left(\frac{D_{ki}^T}{D^T} \right)_{m,n} \right] \left[\frac{(C_i)_{m,n+1} - (C_i)_{m,n}}{\Delta \Psi} \right] - \text{PARTC2}$$

5. Boundary layer swallowing and expansion of the boundary layer

An input number ϵ_H is used as a test value for calling a new inviscid streamline and to increment the Ψ grid. Two options are available based upon the value of ϵ_H . If $\epsilon_H = 0$, the streamline test is

not made. If ϵ_H is set to any positive number (the tolerance) the test

$$\left| \frac{H_{m+1}(L+1) - H_{m+1}(L-1)}{H_{m+1}(L+1)} \right| \leq \epsilon_H$$

is made. If the test fails, a new streamline is computed, or constant edge conditions are carried over.

6. Boundary conditions

a. Initial - an input enthalpy profile vs. physical coordinates.

b. Wall - $H_{m+1} = HH_1 + HH_2 \left(\frac{x}{Rn} \right) + HH_3 \left(\frac{x}{Rn} \right)^2 + HH_4 \left(\frac{x}{Rn} \right)^3 + HH_5 \left(\frac{x}{Rn} \right)^4$ where the HH_1 through HH_5 are input.

c. Outer edge

Enthalpy at the outer edge is obtained from the finite difference equation in Subsection II.D.2. or set equal to the input free stream value accordingly as the momentum, species or enthalpy slope tests are satisfied or not (see Subsections II.B.5., II.C.5., II.D.5. for formulation of tests).

III. INVISCID FLOW EQUATIONS

A. Governing Equations for One-Dimensional Streamlines

1. Momentum

$$u_{\text{inv}} \frac{du_{\text{inv}}}{ds} = - \frac{1}{\rho_{\text{inv}}} \frac{dp}{ds}$$

2. Species

$$u_{\text{inv}} \frac{dc_{i\text{inv}}}{ds} = \frac{\dot{w}_i}{\rho_{\text{inv}}}$$

3. Total enthalpy (energy)

$$H = \text{constant}$$

$$= h_{\text{inv}} + \frac{u_{\text{inv}}^2}{2}$$

B. Tracing the Streamline from the Shock

Reference: NACA Report #1135 - "Equations, Tables and Charts for Compressible Flow 1953"

1. Intersection of streamline and shock, see sketch.

$$\frac{D_{\infty}}{2} = \left(\frac{m_{bL}}{\rho_{\infty} u_{\infty} \pi} \right)^{\frac{1}{2}}$$

where

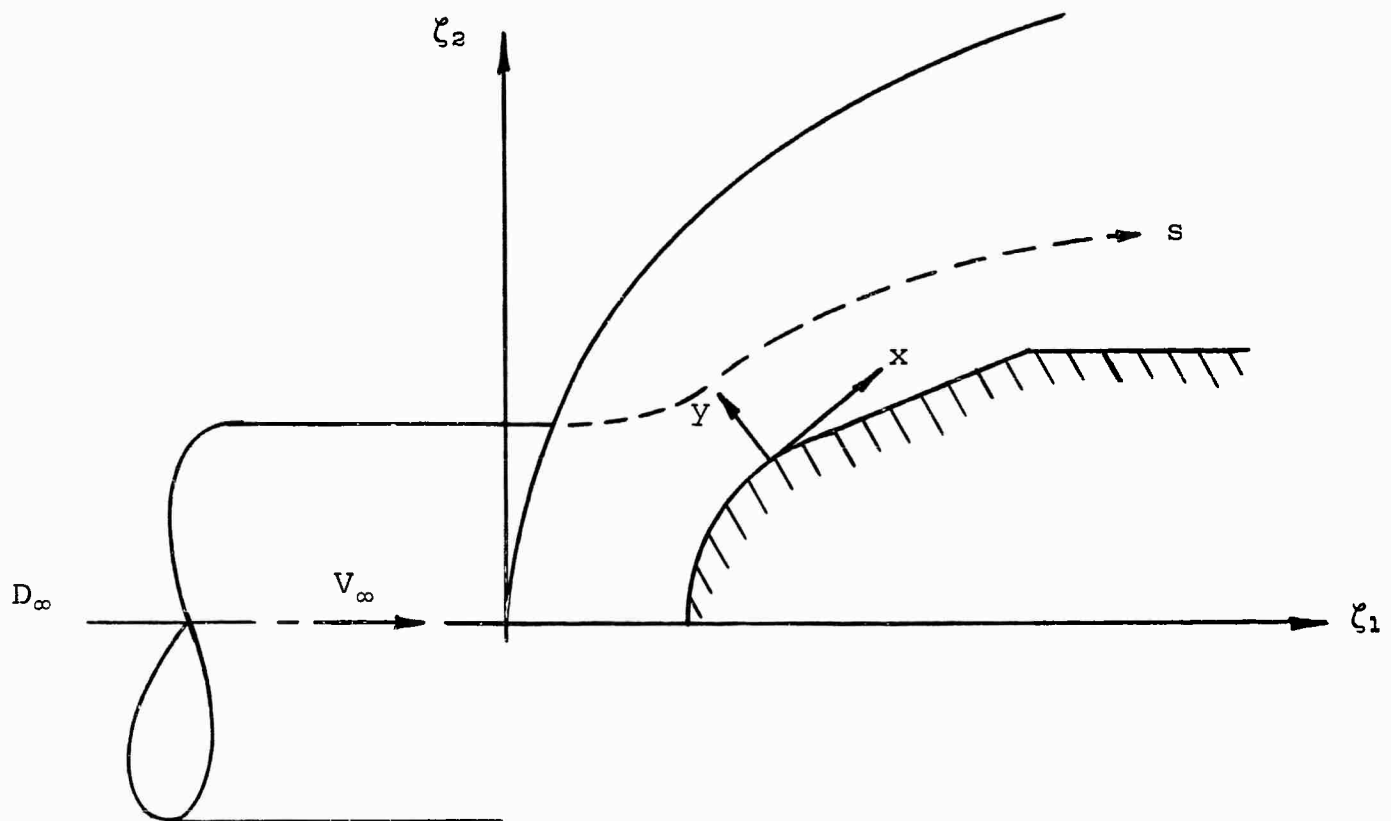
$$m_{bL} = \int_0^{\Psi_e} \epsilon \left[(2\pi) \epsilon_Y \cos \theta_t \frac{d\Psi}{r\epsilon} \right] + (2\pi) \epsilon \Psi_e$$

$\theta_t = 90 - \alpha$, for arc, ogive

= 0, cylinder, flat plate

= cone angle, cone

α = angle which the current point on the body and the coordinates of the center of the arc make with ζ_1 axis, measured in a clockwise direction from ζ_1 .



Coordinate Systems for a Blunt Body

2. Conditions downstream of the shock

a. Following will be input

$$\rho_{\infty}$$

$$\rho_{\text{stag}}$$

$$\left. \begin{array}{l} h_{\infty} \\ c_{p_{\infty}} \end{array} \right\} \text{ needed for } T_{\infty} = \frac{h_{\infty}}{c_{p_{\infty}}}$$

$$p_{\infty}$$

altitude

γ (specific heat ratio)

u_{LOLIM} - used for checking against calculated u in the one-dimensional streamline equation in order to keep $u > 0$.

b. Following will be program set from input

$$u_{\infty} = u(L)$$

$$c_{i_{\infty}} = c(L, I)$$

$$H_{\infty} = H(L)$$

c. The program calculates:

$$u_{\text{ds}} = 1 - \left[\frac{[4(M_1^2 \sin^2 \theta - 1)(\gamma M_1^2 \sin^2 \theta + 1)]}{[(\gamma + 1)^2 M_1^4 \sin^2 \theta]} \right]^{\frac{1}{2}} u_{\infty}$$

where

$$M_1 = \frac{u_\infty}{a_\infty} \text{ Mach \#}$$

$$a_\infty = \text{speed of sound} = 49.9 \sqrt{1.8 T_\infty}$$

$$T_\infty = \frac{h_\infty}{C_{p_\infty}} \text{ } ^\circ\text{K}$$

$$\theta = \angle \text{ shock wave makes with } \zeta_1$$

$$c_{ids} = c_{i_\infty}$$

$$p_{ds} = \left[\frac{2\gamma M_1^2 \sin^2 \theta - (\gamma - 1)}{\gamma + 1} \right] p_\infty$$

d. The program outputs:

(a) p_{ds}

(b) u_{ds}

(c) c_{ids}

3. Completion of streamline calculation

The program sets:

$$u_{m+1}(L) = u_{m+1}(L+1) = u_{m+1}(L+2)$$

$$c_{m+1}(L, I) = c_{m+1}(L+1, I) = c_{m+1}(L+2, I)$$

IV. INPUTS

Under this section the various input parameters are discussed from a programming viewpoint; see Manual, Part III, for input data preparation. In Subsection A through C, certain critical parameters are discussed, and in Subsection D the input definitions and card formats are specified. Also included in the latter sections of this report is a sample problem which illustrates the nature of the inputs.

A. Body Geometry

1. Classification

Bodies will be classified accordingly as the first geometrical region is:

- a. Blunted $\Delta s \neq 0$
 - (a) arc (hemispherical nose)
- b. Pointed $\Delta s = 0$
 - (a) cone
 - (b) ogive
 - (c) flat plate

where Δs = standoff distance from shock to stagnation point of body along centerline (see IV.B.3).

2. Subsequent geometric regions of the body

The following geometrical descriptions for body sections are available:

- | | | |
|---------------|---|--|
| a. arc | } | 2 dimensional or axisymmetric
depending upon input ϵ , (or EPSI in
the input list, Subsection IV.D) |
| b. cone | | |
| c. cylinder | | |
| d. ogive | | |
| e. flat plate | | |

3. Calculation of radius of the body and the ζ_1 , ζ_2 coordinates

a. For each region the program reads in

- | | | | |
|-----|---------------------------|---|----------------|
| (a) | INDP = pressure type | } | 1 = cosine |
| | indicator | | 2 = polynomial |
| | (see p.39, Section C) | | 3 = quotient |
| (b) | INDR = geometry indicator | } | 1 = arc |
| | | | 2 = cone |
| | | | 3 = cylinder |
| | | | 4 = ogive |
| | | | 5 = flat plate |
| (c) | INDLR = last subregion of | } | 1 = yes |
| | last region indicator | | 0 = no |

- (d) INDLSR = last subregion of any region indicator $\left\{ \begin{array}{l} 1 = \text{yes} \\ 2 = \text{no} \end{array} \right.$
- (e) OGIVE H $\left\{ \begin{array}{l} \text{coordinates of center of arc} \\ \text{with respect to } \zeta_1, \zeta_2 \text{ origin} \end{array} \right.$
OGIVE K
- (f) $p(J)$, $J = 1, 8$, pressure coefficients
- (g) $CC_i(K)$, $K = 1, 5$, C_{WALL} coefficients
- (h) R_n = nose or reference base radius
- (i) XL = cumulative upper $\frac{x}{R_n}$ limit of this subregion
- (j) CONEAN = cone angle/2 (vertex semi-angle)

B. Shock Geometry

1. Description of the Shock

The shock consists of up to 10 sections of the form:

a. $\zeta_2 = a_n \zeta_1 + b_n$ straight line

b. $\zeta_1 - a_n = b_n (\zeta_2 - c_n)^2$ parabola

Type 6 is a parabola whose coefficients a_n , b_n and c_n are specified as input. Type 7 is a parabola whose beginning and ending slopes and the ζ_1 projection of the end point of the geometrical shock region are specified as input.

The present version of the program permits parabolas to follow each other but they may not follow straight lines.

2. Shock input is specified by giving

- a. Curve type
- b. Slope and cumulative ζ_1 limit for a straight line
- c. Coefficients and cumulative ζ_1 limit for a parabola or
- d. Beginning and ending slopes and cumulative ζ_1 limit

3. Section 1 of the shock has optional provision (type 7) for internally computing and establishing the shock

$$\zeta_1 - a_n = b_n (\zeta_2 - c_n)^2$$

with

$$a_n = c_n = 0, \quad b_n = \frac{.5}{1 + \frac{\Delta s}{Rn}} \frac{1}{Rn}$$

where $\Delta s = \frac{2/3}{\frac{\rho_{stag}}{\rho_\infty} - 1} Rn$ (physical standoff distance). $\frac{\Delta s}{Rn}$ is the

dimensionless standoff distance.

4. The program has provision for specifying several shock shapes, e.g. conical, parabolic and normal. Moreover optional modes for specifying a particular shape are also possible, e.g.

parabolas can be specified by inputting the coefficients of the analytic expression or the beginning and ending slopes. The following indicates the formulae for obtaining the ζ coordinates and the balances of the shock coefficients for all permissible combinations of shock shapes.

a. Region 1 is a cone

i. $m, \zeta_1, b_1 = 0$ are input

ii. $\zeta_2 = m \zeta_1$

b. Region N-1 is a parabola

Region N is a parabola - Type 6

i. $a_{N-1}, b_{N-1}, c_{N-1}$ are available

a_N, b_N, c_N are input

ii. $\zeta_{1(N-1)} = a_{N-1} + b_{N-1} [\zeta_{2(N-1)} - c_{N-1}]^2$

$$\zeta_2 = \frac{b_{N-1} c_{N-1} - b_N c_N}{b_{N-1} - b_N}$$

c. Region N-1 is a parabola

Region N is a parabola - Type 7

i. $a_{N-1}, b_{N-1}, c_{N-1}$ are available

m_{N-1}, m_N, ζ_{1N} are input

$$\text{ii. } a_N = \frac{\zeta_1(N-1)m_{N-1}^2 - m_N^2 \zeta_1(N)}{m_{N-1}^2 - m_N^2}$$

$$c_N = \zeta_2(N-1) - \frac{2m_N^2(\zeta_1(N) - a_N)}{m_{N-1}}$$

$$b_N = \frac{1}{4m_N^2(\zeta_1(N) - a_N)}$$

$$\zeta_2(N-1) = \frac{1}{2b_{N-1} m_{N-1}} + c_{N-1}$$

$$\zeta_1(N-1) = a_{N-1} + b_{N-1}(\zeta_2(N-1) - c_{N-1})^2$$

d. Region N-1 is a parabola

Region N is a cone

i. a_{N-1} , b_{N-1} , c_{N-1} are available

m_N is input

$$\text{ii. } \zeta_2(N-1) = \frac{1}{2b_{N-1} a_N} + c_{N-1}$$

$$\zeta_1(N-1) = a_{N-1} + b_{N-1}[\zeta_2(N-1) - c_{N-1}]^2$$

$$b_N = \zeta_2(N-1) - a_N \zeta_1(N-1)$$

e. Region N-1 is a cone

Region N is a cone

i. a_{N-1} , b_{N-1} , $\zeta_1(N-1)$ are available

m_N is input

ii. $\zeta_2(N-1) = a_{N-1} \zeta_1(N-1) + b_{N-1}$

$$b_N = \zeta_2(N-1) - a_N \zeta_1(N-1)$$

C. Pressure Distribution

Associated with each body subregion is a distribution which is one of 3 possible types:

$$1. \quad p = p_1 \cos^2 \frac{x}{Rn} \quad (\text{Newtonian})$$

$$2. \quad p = p_2 + p_3 \frac{x}{Rn} + p_4 \left(\frac{x}{Rn} \right)^2 + p_5 \left(\frac{x}{Rn} \right)^3 + p_6 \left(\frac{x}{Rn} \right)^4$$

$$3. \quad p = \frac{p_7}{p_8 + \frac{x}{Rn}}$$

where p_1 through p_8 are inputs.

D. Input Definitions, Card Formats and Symbols

<u>SYMBOLS</u>	<u>DEFINITION</u>	<u>FORMAT</u>
*LP2	# Ψ pts + 2	I 10
NS	# species	
NPSI	print interval density in Ψ direction e.g. every point, every second point, etc.	
INDSTR	streamline starting point indicator	
FNDSSL	lower limit for step size control	E 10.3
FNDSSH	upper limit for step size control	
IALT	altitude - in kft	I 10
A_1^L	laminar indicator for momentum equation	E 10.3
A_1^T	turbulent indicator for momentum equation	
A_2	chemistry indicator for equilibrium or non- equilibrium calculations (see p.18, Section b)	
A_3^L	laminar indicator for species equation	
A_3^T	turbulent indicator for species equation	
A_4^L	laminar indicator for energy equation	
A_4^T	turbulent indicator for energy equation	
A_5^L	laminar indicator for energy equation	
A_5^T	turbulent indicator for energy equation	
c(N,I)	species mass fraction profiles N = 1,2...LP2; I = 1,2,4,5,6	
*RESTAR	restart indicator; 1 = original run, 0 = continuation run	E 10.3

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
DELTAx	step size - x direction	E 10.3
EPSI	exponent for body radius	
EPSIU= ϵ_u	tolerance on velocity for a streamline call	
EPSIC= ϵ_c	tolerance on all species for a streamline call	
EPSIH= ϵ_H	tolerance on total enthalpy for streamline call	
EPSIT= ϵ_T	tolerance on temperature iteration	
FH(N)	total enthalpy profile, N = 1,2...LP2	
FK	factor in $\frac{-T_1}{\mu}$	
*CPE	free stream specific heat at constant pressure	E 10.3
FL	characteristic length to dimensionalize species production term	
FSHE	free stream static enthalpy	
GAMM	ratio of specific heat, Cp/Cr	
PE	free stream pressure	
RHOE	free stream density	
RHOSTG	stagnation density	
CE(I)	free stream species, I = 1,2...7	
R _N	nose radius	
UINF	free stream velocity	
ULOLIM	low limit for velocity in streamline	
XS	x starting value	

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
Z1S	ζ_1 coordinate starting value	E 10.3
Z2S	ζ_2 coordinate starting value	
Z1L	ζ_1 coordinate entire body	
u(N)	velocity profile, $N = 1, 2, \dots, LP2$	
*FA	coefficient for FKPSI in μ^{T2} FKPSI \equiv K(N) (see p.8, Section ii)	E 10.3
FB		
FC		
TESTRA	test ratio for establishing turbulent viscosity model	
AB ₁ ^T	law of the wall - dimensional coordinate y law of the wake - dimensional coordinate, y_e laminar viscosity eddy viscosity fit dimensional coordinate y law of the wall - streamline coordinate, Ψ law of the wake - streamline coordinate, Ψ_e eddy viscosity fit streamline coordinate, Ψ law of the wall - dimensional coordinate, y	E 10.3
AB ₂ ^T		
AB ₃ ^T		
AB ₄ ^T		
AB ₅ ^T		
AB ₆ ^T		
AB ₇ ^T		
BB ₁ ^T		

Indicators and
coefficients for
invoking turbulent
viscosity model
components
(see p.7, Section 4,b)

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
BB ₂ ^T	law of the wake - dimensional coordinate, y_e	E 10.3
BB ₃ ^T	laminar viscosity	<div>Indicators and coefficients for invoking turbulent viscosity model components (see p.7,Section 4,b)</div>
BB ₄ ^T	eddy viscosity fit dimensional coordinate, y	
BB ₅ ^T	law of the wall - streamline coordinate, Ψ	
BB ₆ ^T	law of the wake - streamline coordinate, Ψ_e	
BB ₇ ^T	eddy viscosity fit streamline coordinate, Ψ	
FLELIN	Lewis laminar number	E 10.3
FLETIN	Lewis turbulent number	
PRALIN	Prandtl laminar number	
PRATIN	Prandtl turbulent number	
SCHLIN	Schmidt laminar number	
SCHTIN	Schmidt turbulent number	
Y(N)	physical coordinates for input profile normal to body	
*INDPRI	print interval x direction	I 10
NSR	# shock regions	
JINPUT	# times to bypass step size control halving	
THPER	% to be used to establish boundary layer thickness	E 10.3

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
*ASR(N)	coefficients for N^{th} shock region geometry, $N = 1, \text{NSR}$	E 10.3
BSR(N)		
CSR(N)		
Z1R(N)	ζ_1 boundary for N^{th} shock region, $N = 1, \text{NSR}$	
Z2R(N)	ζ_2 boundary for N^{th} shock region, $N = 1, \text{NSR}$	
INDTYP(N)	geometric type, $N = 1, \text{NSR}$	I 3
INDCOO(N)	end coordinate indicator, $N = 1, \text{NSR}$	I 3
INDLAS(N)	last shock region indicator, $N = 1, \text{NSR}$	I 4
Note: ASR(N)-INDLAS(N) are repeated for each shock region, $N = 1, \text{NSR}$		
*INDP	body subregion pressure type	I 10
INDR	body subregion geometric type	
INDLR	last region indicator	
INDLSR	last subregion indicator	
INDS5	spare	
INDS6	spare	
INDS7	spare	
OGIVEH	coordinates of center of body arcs or ogives	E 10.3
OGIVEK		
P(J)	coefficients for pressure formulas, $J = 1, 8$	
CC(K,I)	coefficients for species mass fractions at wall, $K = 1, 5; I = 1, \text{NS}-1$	

<u>SYMBOL</u>	<u>DEFINITION</u>	<u>FORMAT</u>
HH(J)	coefficients for total enthalpy at wall, J= 1,5	↓
R _N	body radius	
X _L	cumulative x limit for each subregion	
CONEAN	cone angle	

Note: INDP-CONEAN are repeated for each body subregion

* Indicates that this field is the first one on the input card, and subsequent fields until the next * are continuous through column 70 for as many cards as are necessary.

V. PROGRAM FEATURES

A. Step Size Control

The purpose of step size control is to allow the program to run as fast as possible within stability and truncation requirements.

1. Ψ direction

Whenever the number of Ψ intervals becomes twice the original input amount (as a result of swallowing) the program halves the number of points. This is of significance since the permissible stability control step size in the x direction varies with $(\Delta\Psi)^2$.

2. x direction

The program takes two single steps and compares the velocity, species and enthalpy with the results of a single step of double size. Depending on input limit tolerances, the step size is doubled, unchanged or halved. However, the step size is always subjected to the stability control for maximum size.

If a negative velocity, specie, enthalpy or temperature has been calculated, or depending on a sense switch being on, if a 5% out of monotonicity in u or H develops, the step size is halved up to seven times before the program stops. Provision has been made for overriding the halving for JINPUT times, so as

to allow zero species to fill in as a result of production and of diffusion in the Ψ direction. The above procedure for doubling, continuing and halving the step size which applies to the boundary layer also applies individually to u and c_i in the streamline calculations.

B. Stability Control

The expansion of the step size in the x direction which is described under "Step Size Control" is subsequently scrutinized to insure stability.

Δx is compared to $\frac{\overline{\Delta \Psi^2}}{2\sigma_n}$ and accordingly as it is less than (or equal to) or greater than, it is accepted or halved.

$$\sigma_u = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n A_1^L \mu_n^L + A_1 \left[\frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \right]$$

$$\sigma_H = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_4^L \frac{\mu_n^L}{P_{r_n}^L} + A_4^L \frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \frac{1}{P_{r_n}^T} \right]$$

$$\sigma_C = r_m^{\epsilon} r_m^{\epsilon} \rho_n u_n \left[A_3^L \frac{\mu_n^L}{S_{c_n}^L} \frac{D_k^L}{D_n^L} + A_3^T \frac{\overline{\mu}_{n+1/2}^T + \overline{\mu}_{n-1/2}^T}{2} \frac{1}{S_{c_n}^T} \frac{D_k^T}{D_n^T} \right]$$

Δx must be \leq the minimum of $\frac{\overline{\Delta \Psi^2}}{2\sigma_u T \ln}$, $\frac{\overline{\Delta \Psi^2}}{2\sigma_H T \ln}$, $\frac{\overline{\Delta \Psi^2}}{2\sigma_C T \ln}$ in order to insure stability.

C. Conversion from Physical to Streamline Coordinates

1. The various input profiles are given as functions of the physical coordinate Y , which may be unevenly spaced. The number of Ψ intervals equals the input number of Y intervals and is equal to $L - 1$.
2. The streamline coordinate $\Psi = \int_0^Y \rho u r^\epsilon dy$ is calculated and then equispaced over the thickness.
3. The corresponding Y 's are developed from $Y = \int_0^\Psi \frac{1}{\rho u r^\epsilon} d\Psi$ with $Y(0) = 0$.
4. A table lookup routine is used to linearly interpolate the dependent variables, u , C_i , H .
5. The calculated value of Y_{\max} is compared with the input value of Y_{\max} (see Input, Section IV.D). If the difference is greater than .1%, the following on line message is printed: "YCALC(L) = $Y(L)$ = ".

D. Continuation Procedure

At any time during the running of the program sense switch 4 can be depressed and an on-line punch of the continuation quantities will occur. This makes it possible to continue the program at a later date.

When the program is continued with on-line punched cards,

RESTAR must be set equal to zero.

E. Output Control

Based on the input quantity INDPRI, output at every n^{th} station is obtained and based on NPSI, output at every m^{th} Ψ level. There is also provision in the streamline calculation to obtain output whenever the step size doubles.

F. Streamline Control

An initial value or a complete body problem can be solved depending on whether we input a 0 or 1 for INDSTR. Thus there are two possible starting points for a streamline calculation:

1. The starting profile at the starting point on the body.
2. The starting profile at the point of intersection of the streamtube and the shock.

In addition, the first option can be additionally modified to constant edge conditions, i.e., $u_{m+1}(L+3) = u_e$,

$C_{i,m+1}(L+3) = C_{e,i}$, $H_{m+1}(L+3) = H_e$, by setting INDSTR = - 1.

G. Sense Switch Control

Is available for diagnostic and monitoring purposes and can be specifically determined by consulting the source language.

H. Additional Programming Logic

1. Momentum equation

- a. In order to step forward the required ρ is obtained as follows:

$$h(\Psi) = H(\Psi) - \frac{u^2(\Psi)}{2}$$

Using as our first approximation for T

$$T_i(\Psi) = \left[h - C_O \frac{D_{O2}}{2m_O} - C_N \frac{D_{N2}}{2m_N} - \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) \frac{C_{NO+}}{m_{NO+}} \right. \\ \left. \left(I_{NO} + \frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) \right] / C_P$$

calculate

$$\Lambda_j = \left(\frac{T_j^V}{T} \right) / \left(e^{T_j^V / T} - 1 \right)$$

and solve for T_{i+1}

$$h = RT_{i+1} \left[\sum_j \frac{C_j}{M_j} \left(\Lambda_j + \frac{7}{2} \right) + \frac{5}{2} \sum_k \frac{C_k}{M_k} \right] + C_O \left(\frac{D_{O2}}{2m_O} \right) + C_N \left(\frac{D_{N2}}{2m_N} \right) \\ + \frac{C_{NO}}{m_{NO}} \left(\frac{D_{N2} + D_{O2}}{2} - D_{NO} \right) + \frac{C_{NO+}}{m_{NO+}} \left(I_{NO} + \frac{D_{N2} + D_{O2}}{2} - D_{NO} \right)$$

$$j = O_2, N_2, NO, NO^+$$

$$k = O, N, e$$

if $\left| \frac{T_{i+1} - T_i}{T_{i+1}} \right| < \epsilon_T$ we use T_{i+1} , otherwise continue the iteration cycle at Λ .

- b. $p(x)$ is chosen according to the indicator for the subregion and we compute

$$\rho = \frac{p}{RT \sum_i \frac{C_i}{M_i}}$$

- c. Because the nature of the u profile is not linear in the neighborhood of the wall, $u_{1/2}$ is obtained by assuming $u = a\Psi^{1/2} + b\Psi$ and determining a and b from u_2 and u_3 . The derivative at the $1/2$ point is obtained by differentiating u .
- d. If a velocity is negative or if both sense switch 5 is depressed and a 5% out of monotonicity occurs, then the step size is halved and the calculation repeated. If after halving seven times, the velocity is still negative, the program stops.

2. Species equation

If a species is negative, the step size is halved and the calculation repeated. If after halving the step size seven times, a species is still

negative, the program stops. $C_{1/2}$ is obtained by assuming $C = C_w + a\Psi^{1/2} + b\Psi$ and determine a and b from C_2 and C_3 . The derivative at the $1/2$ point is obtained by differentiating C .

3. Enthalpy equation

Halving of the step size will result when a negative enthalpy occurs.

If after seven halvings, this condition persists, the program will halt.

$H_{1/2}$ is obtained by assuming $H = H_w + a\Psi^{1/2} + b\Psi$ and determine a and b from H_2 and H_3 . The derivative at the $1/2$ point is obtained by differentiating H .

VI. PROGRAMMED STOPS AND PAUSES

<u>PROGRAM</u>	<u>STOP NO.</u>	<u>MEANING</u>
	Displayed in Address Field of Storage Register	
MAIN	17	$\epsilon < 0$
	77	Shock geometry is cone followed by parabola
	310	$A_i^{L,T} < 0$
	650	$K_s < 1$
	2575	$LP_2 \geq 99$
	2655	$L > 2$ (LORIG)
CEDGE(J)	60	$J < 1$
	71	$C_{w,i}$ or $\sum C_{w,i}$ is in error
RADBDY	550	$\epsilon < 0$
STEPSZ	603 (Pause)	Δx has been halved 7 times Additional 7 times can be obtained by depressing START
UCSTRE	21	$\frac{D_\infty}{2}$ is not in any shock region
UEDGE(J)	30	$J < 1$
	50	$J > 3$

VII. OPERATING PROCEDURE

A. Original Run

Standard 7094 Fortran operating procedure is employed with RESTAR = 1.0E0. Program language is FORTRAN II.

B. Continuation Run

Remove subregion parameter cards that were read in during previous run. Insert continuation cards after problem input and ahead of remaining subregion cards. Set RESTAR = 0E0.

There is present the option of modifying the original input or the continuation input by repunching the appropriate fields or cards. It should be noted that the continuation cards are necessarily in octal in order to preserve full significance.

APPENDIX 1

DIMENSIONS OF VARIABLES

APPENDIX 1DIMENSIONS OF VARIABLES

The units of the variables which appear in the equations are listed below. The conversion constants required for consistency are indicated.

A. Momentum Equation

1. The units for the quantities involved are

$$\rho = \frac{\text{lb sec}^2}{\text{ft}^4} \text{ or } \frac{\text{slugs}}{\text{ft}^3}$$

$$u = \text{ft/sec}$$

$$p = \text{lbs/ft}^2$$

$$\frac{dp}{ds} = \text{lbs/ft}^2, \text{ s is nondimensional}$$

$$\frac{dp}{dx} = \text{lbs/ft}^3, \text{ x is in feet}$$

$$\tau = \text{lbs/ft}^2$$

$$\mu = \frac{\text{lbs sec}}{\text{ft}^2}$$

$$\frac{d\tau}{dy} = \text{lbs/ft}^3$$

2. In order for ρ to have the units $\frac{\text{lbs sec}^2}{\text{ft}^4}$ R should be expressed in the following units:

$$\frac{\text{lb sec}^2}{\text{ft}^4} = \rho = \frac{P}{RT \sum C/M} = \frac{\text{lb/ft}^2}{R \cdot K \frac{\text{mole}}{\text{gm}}}$$

$$R = \frac{\text{gm ft}^2}{^\circ\text{K mole sec}^2}$$

$$= 8.31657 \times 10^3 \text{ joule (kilogram mole}^{-1}\text{) } ^\circ\text{K}^{-1}$$

$$= \frac{1}{1.356} \frac{\text{ft lbs}}{\text{joules}} 453.6 \frac{\text{gm}}{\text{lb}} 32.2 \text{ ft/sec}^2$$

$$= 8.95805 \times 10^7 \frac{\text{gm ft}^2}{^\circ\text{K (kilogram mole) sec}^2}$$

$$= 8.95805 \times 10^4 \frac{\text{gm ft}^2}{^\circ\text{K (gram mole) sec}^2}$$

3. In order for T to have the units $^\circ\text{K}$ the following adjustments must be made:

$$T = \frac{h - \frac{D_{O_2}}{m_O}}{C_P} = \frac{\frac{\text{ft}^2}{\text{sec}^2} - \left(\frac{\text{ev}}{\text{part}} \right) \frac{1}{\text{gm}}}{\frac{\text{ft}^2}{\text{sec}^2} \text{ K}} = ^\circ\text{K} - \frac{\text{ev sec}^2}{\text{part gm ft}^2} ^\circ\text{K}$$

Taking the second term

$$\frac{\text{ev sec}^2 \text{ } ^\circ\text{K}}{\text{part gm ft}^2} 453.6 \frac{\text{gm}}{\text{lb}} 32.2 \frac{\text{ft}}{\text{sec}^2} \frac{1}{1.356} \frac{\text{ft lb}}{\text{joule}} \frac{1 \text{ joules}}{6.24 \times 10^{18} \text{ ev}}$$

$$= 1726 \times 10^{-18} (^\circ\text{K})$$

Thus for all $\frac{D}{m}$ terms, this factor should be used, i.e.

$$\frac{D}{m} = 1726 \times 10^{-18} \left(\frac{D}{m} \right)$$

B. Species Equation

1. The units for the quantities involved are

$$\dot{w} = \frac{\text{lb sec}}{\text{ft}^4} \text{ which is derived from}$$

$$\dot{w} = \rho u \frac{dc_i}{dx}$$

2. ρ_{DO} should be of the same units as ρ for Eq. (7a),

p. 5 of GASL TR-246. Hence,

$$\rho_{DO} = \frac{\frac{\text{gm/mole}}{\frac{\text{particle}}{\text{mole}}}}{(\text{ft lbs sec})^3} \left(\frac{\text{gm}}{\text{part}} \frac{\text{ft lb}}{^\circ\text{K}} \text{ } ^\circ\text{K} \right)^{3/2}$$

$$= \frac{\frac{\text{gm}^{5/2}}{(\text{ft lbs})^{3/2} \text{ sec}^3 \text{ part}^{5/2}}}{\left(\frac{1}{453.6} \frac{\text{lb}}{\text{gm}} \right)^{5/2} \left(\frac{1}{32.2} \text{ sec}^2/\text{ft} \right)^{5/2}}$$

$$= 3.87871 \times 10^{-11} \frac{\text{lbs sec}^2}{\text{ft}^4} \bar{\rho}_{DO}$$

Similarly for ρ_{DN} , ρ_{DNO} , ρ_{DE}

3. σ, γ, \bar{K} are dimensionless

4. A, B, C, K develop as follows (example for A shown below)

$$\frac{\text{ft}}{\text{gm/mole}} \left[\frac{1}{\text{gm}} \frac{\text{cm}^6}{\text{part}^2 \text{sec}} \right] \left[\frac{\text{lb sec}^2}{\text{ft}^4} \right] \left[\frac{\text{lb sec}^2}{\text{ft}^4} \right]$$

$$A = \frac{\text{mole}^2 \text{cm}^6 \text{sec}^3 \text{lb}^2}{\text{ft}^7 \text{gm}^2 \text{part}^2} \left[453.6 \frac{\text{gm}}{\text{lb}} \right]^2 \left[\frac{1}{2.54} \frac{\text{in}}{\text{cm}} \frac{1}{12} \frac{\text{ft}}{\text{in}} \right]^6 \left[6.0251 \times 10^{23} \frac{\text{part}}{\text{mole}} \right]$$

$$= 4.9778 \times 10^{21} \frac{\text{mole sec}}{\text{part}} \bar{A}$$

5. D, E, F develop as follows (example for D shown below)

$$\frac{\text{ft}}{\text{gm}} \frac{\text{cm}^3}{\text{part sec}} \frac{\text{lb sec}^2}{\text{ft}^4}$$

$$D = \frac{\text{mole cm}^3 \text{sec lb}}{\text{ft}^3 \text{gm part}} 453.6 \frac{\text{gm}}{\text{lb}} \left(\frac{1}{30.48} \frac{\text{ft}}{\text{cm}} \right)^3$$

$$= 1.6018 \times 10^{-2} \frac{\text{mole sec}}{\text{particle}} \bar{D}$$

6. Equation (9), p. 7 of GASL TR-246 would yield (neglecting $\frac{M_O}{\rho}$)

$\Sigma \dot{w}_i = \frac{\text{mole sec}}{\text{part}}$ but $\frac{\text{lb sec}}{\text{ft}^4}$ are required hence

$$\frac{\text{mole sec}}{\text{part}} \rho \frac{\text{lb sec}^2}{\text{ft}^4} 32.2 \text{ ft/sec}^2 6.0251 \frac{\text{part}}{\text{mole}} \times 10^{23} \frac{1}{\text{L}} \text{ ft}$$

$$\dot{w} = 1.94008 \times 10^{25} \frac{\rho}{\text{L}} \left[\right] \frac{\text{lb sec}}{\text{ft}^4} \bar{w}_i$$

7. In A, B, etc. $\frac{D_{O2}}{KT}$ should be dimensionless. This can be accomplished by setting

$$\begin{aligned} \frac{D_{O2}}{KT} &= \frac{\frac{\text{ev}}{\text{particle}}}{\frac{\text{ft lbs}}{\text{°K}}} \times 1.356 \frac{\text{joules}}{\text{ft lb}} 10^7 \frac{\text{erg}}{\text{joule}} \frac{1}{1.6021 \times 10^{-12}} \frac{\text{ev}}{\text{erg}} \\ &= .846389 \times 10^{19} \left(\frac{D_{O2}}{KT} \right) \end{aligned}$$

C. Energy Equation

1. The units for the quantities involved are:

$$H = -\frac{\text{ft}^2}{\text{sec}^2}$$

$$h_i = \frac{\text{ft}^2}{\text{sec}^2}$$

$$D_{Ki} = \frac{\text{ft}^2}{\text{sec}}$$

APPENDIX II

PROGRAM SOURCE LANGUAGE

78MR-17

[illegible]

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CHNREL

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C  PARABOLA PARABOLA 7
87  SLCFEI=ASR(N)
   SLCFE2=RSK(N)
   Z2R(N-1)=.5/BSH(N-1)/SLCFEI*(SRIN-1)
   IF JINCLCCL(N-1) 6,8,85
88  Z1R(N-1)=ASR(N-1)+BSR(N-1)*(Z2R(N-1)-(SRIN-1))**2
89  ASR(N)=(Z1R(N-1)+SLCFEI**2-SLCFE2**2+Z1R(N))/(-SLCFEI**2-SLCFE2**2)
   CSK(N)=Z2R(N-1)-2-C*SLCFEI2**2+Z1R(N)-ASR(N)/SLCFEI
   ESR(N)=.25/SLCFEI2**2+Z1R(N)-ZSR(N)
   GC TC 55
90  IF (INDTYP(N-1)-1) 100,100,91
91  IF (INDTYP(N-1)-2) 52,54,54
92  Z2R(N-1)=ASR(N-1)*Z1R(N-1)+ESR(N-1)
   CL TC 100
94  Z2R(N-1)=CSK(N-1)+SLCFEI*(Z1R(N-1)-ASR(N-1))/ESR(N-1)
   GC TC 100
95  N=N+1
   GC TC 63
100 IF (NSTART) 210,175,210
175 READ INPUT TAPE 5,2761,KS,INDF(N),N=1,KS),L,L*2,(INDFSL,INDP,INDR
   1,INCLC,IRCLSK
180 READ INPUT TAPE 5,2765,X,DELTA,X,IL (N),N=1,L*2).
   1000 (N,A),N=1,L*2),N=1,KS),IFM (N),N=1,L*2),PSI(N),N=1,L*2),
   2DELTA,P,(Y),N=1,L*2),Z1,Z2,Z1S,Z2S,LEIVER,CGIVER,(P(J),J=1,8),
   3(ILLU),N=1,5),I=1,KS),IF(J),J=1,5),KN,XL,CUNEAN,((PSI(J),J=1,
   48),J=1,KS),IRFS(N),N=1,KS),XLS(N),N=1,KS),ALPHA,XS,RS,RSR
   CALL CCONFAC(3)
   GL TC 680
210 CALL STACUT(1)
300 INDFSL=C
305 IF (Z1L) 310,315,315
310 STCF 310
315 IF (Z1L) 310,325,325
325 IF (Z1L) 310,335,335
335 IF (Z1L) 310,345,345
345 IF (Z1L) 310,355,355
355 IF (Z1L) 310,365,365
365 IF (Z1L) 310,375,375
375 IF (Z1L) 310,400,400
400 X=X+DELTA
500 FORPAT (711C,(7E1C,3))
510 READ INPUT TAPE 5,500,INDP,INDR,INDL,INCLSK,INDS5,INDS6,INDS7,
   10GIVER,UGIVER,(P(J),J=1,8),((C(K),K=1,5),I=1,NSPI),((PH(J),J=1,5
   2),KN,XL,CUNEAN
   GC TC 1520,540,540,520,540),INCR
520 IF (GOLIVER-Z1S) 521,522,523
521 ALPHA=3.14159266-ATANF(ABSF((Z2S-CGIVER)/(GGIVER-Z1S)))
   GC TC 540
523 ALPHA=ATANF((Z2S-CGIVER)/(GGIVER-Z1S))
   GC TC 540
526 ALPHA=1.57079633
540 KS=KS+1
   INDFSL(KS)=INDF
545 CC 550 J=1,8
550 PSI(J,KS)=F(J)
   RNS(KS)=KN

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13-00000

[illegible]

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211/SCF(N+1)+UMDT(N,1)/SCF(N))+(C(N+1,1)-C(N,1))/DELTA-DSCR2)
IF(I2-5.8) 2424,2424,2420
2420 CM(N,1)=C(N,1)+DELTA*WCT(N,1)/RHC(N)/L(N)+DELTA*RS*DSCRIP/DELTA
IF
GL TC 2425
2424 CM(N,1)=C(N,1)+DELTA*WCT(N,1)+A2/RHC(N)/L(N)+DELTA*RS*DSCRIP/D
1ELTAF
2425 CONTINUE
CECLE(1) IS SMALL
IF(I2-5.8) 2430,2430,242E
242E CALL CELGELS,1,1)
GL TC 2431
2430 CALL CELGELS,1,1)
2431 CALL CELGELS,1,1)
2500 CALL FSLCT
IF(I2) 2501,2502,2502
2501 CALL CELGELS,1,1)
2502 IF(I2-5.8) 2508,2508,250E
2505 IF(I2-5.8) 2508,2508,250E
250E IF(I2-5.8) 2510,2510,251E
2510 IF(I2-5.8) 2510,2510,251E
251E IF(I2-5.8) 2510,2510,251E
2520 IF(I2-5.8) 2510,2510,251E
252E IF(I2-5.8) 2510,2510,251E
2525 IF(I2-5.8) 2510,2510,251E
2530 IF(I2-5.8) 2510,2510,251E
IF(I2-5.8) 2510,2510,251E
2540 CONTINUE
2560 GL TC 260E
2563 FHM(L+3)=FHE
PRINT 2565,L,UM(L-1),LM(L+1),CM(L-1,1),I=1,5),CM(L+1,1),I=1,5),
IFHM(L-1),FHM(L+1)
2565 FORMAT(4F L=13,1P7E13.5/1P7E13.5)
CALL LCSTRE
L=L+1
LP2=LP2+1
UM(L-4)=UM(L-4)/UM(L-1)*LP(LF2)
UM(L-3)=UM(L-3)/UM(L-1)*LP(LF2)
UM(L-2)=UM(L-2)/UM(L-1)*LP(LF2)
UM(L-1)=UM(L-1)/UM(L-1)*LP(LF2)
CM(L)=LP(LF2)
UM(L+1)=UM(L+1)
IF(EPSIC) 2567,256E,2567
2567 LC 2570 I=1,NS
CM(L-4)=(CM(L-4)/CM(L-1))*CM(LP2,1)
CM(L-3)=(CM(L-3)/CM(L-1))*CM(LP2,1)
CM(L-2)=(CM(L-2)/CM(L-1))*CM(LP2,1)
CM(L-1)=(CM(L-1)/CM(L-1))*CM(LP2,1)
CM(L)=CM(LP2,1)
2570 CM(L+1)=CM(LP2,1)
GC TC 2573
2568 DL 2565 I=1,NS
CM(L,1)=CM(LP2,1)
2565 CM(L+1,1)=CM(LP2,1)
2573 CALL LCPAG(3)
IF(LP2-59) 2600,2575,2575

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2575 STCF 2575
2600 CC 2604 N=1,LP2
      L(N)=L(N)
      CC 2602 I=1,NS
2602 C(N,I)=CM(N,I)
2604 FH(N)=FF(N)
      LALL STALUT(S)
      X=X+DELTAX
      RS=RSP
      CC TC 2650
2606 CALL STEPS2
2610 IF (INCLSF-2) 700,800,2700
2650 IF (L+1-2*LCRPI) 2700,2600,2655
2655 STCF 2655
2660 CC 2670 N=2,LCRPI
      N2=2*N-1
      L(N)=L(N2)
      CC 2665 I=1,NS
      C(N,I)=C(N2,I)
      FH(N)=FH(N2)
      PSI(N)=PSI(N2)
2670 Y(N)=Y(N2)
      L=LCRPI
      LP2=L+2
      C(LF2)=C(LCRPI)
      CC 2675 I=1,NS
2675 C(LF2,I)=C(LCRPI,I)
      FH(LF2)=FH(LCRPI)
      DELTAP=2.0*DELTAF
      PSI(LF2)=PSI(LCRPI)+DELTAF
      CALL CCNPRG(3)
2680 PRINT 2685,JS
2685 FORMAT(21F,NC,FSI,PTS,1/2,JS=16)
2700 IF (INCLFSU) 2750,2750,3000
2750 IF (X-XL) 2755,2775,2900
2755 IF (SENSE SWITCH 4) 2760,700
2760 FUNCH 2761,KS,(INCLPS(N),N=1,KS),L,LP2,INCLFSU,INCL,INCLR,INCL
1R
2761 FCNPRG(1415)
2763 PUNCH 2765,X,DELTAX,(U(N),N=1,LP2),
      1 ((C(N,I),N=1,LP2),I=1,NS),(FH(N),N=1,LP2),(PSI(N),N=1,LP2),
      2 DELTAP,(Y(N),N=1,LP2),Z1,Z2,Z3,Z5,CGIVEH,CGIVEK,(P(J),J=1,8),
      3 ((C(N,I),N=1,5),(FH(J),J=1,5),RAX,AL,CUNEAN,(PS(J,I),J=1,
      48),I=1,KS),(RAS(N),N=1,KS),(XLS(N),N=1,KS),ALPHA,XS,RS,RSM
      CC TC 3030
2765 FORPAT(6C12)
2775 DELTAX=DELTAX
2800 INCLFSU=1
      GC TC 700
2900 DELTAX=DELTAX
      DELTAX=DELTAX-(X-XL)
      X=X-DELTAX+DELTAX
      GC TC 2800
3000 IF (INCLSR) 3100,3100,3020
3020 IF (INCLR) 3100,3100,3030
3030 X=X-DELTAX

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CHMRBL

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STORAGE NOT USED BY PROGRAM

LEC CCT
2117 64105

LEC CCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

ALL 32561 77461	LEC CCT	ALL 32560 77460	LEC CCT	A3L 32558 77457	DEC OCT	A3T 32557 77455	DEC OCT
A4L 32556 77454		A4T 32555 77453		A5L 32554 77452		AAU 23204 55244	
A6T 32552 77450		A6T 32551 77447		A6T 32550 77446		ABST 32548 77444	
ABST 32547 77443		ABT 32546 77442		AC12 32545 77441		ALPHA 32534 77422	
ASH 32533 77425		AL12 32523 77413		B1T 32522 77412		B3T 32402 77222	
B4T 32342 77126		B5T 32262 77032		B6T 32222 76736		B8T 32102 76546	
B8T 32101 76545		B8T 32100 76544		B8T 32095 76543		B8T 32097 76541	
B8T 32056 76540		B8T 32055 76537		B8T 32054 76525		BSR 32024 76430	
B012 32014 76410		C12 31413 75265		CC12 31353 75171		CE 30753 74041	
CMI 30143 72677		C2 30133 72665		CM 30743 74027		CPE 29531 71533	
CP 29532 71534		C 32013 76415		CSR 28930 70402		CSUB 23314 55256	
DCDU12 28520 70370		DEL 28910 70356		DELTA 28909 70355		DELXOD 28907 70353	
DELXST 28906 70352		DEL12 28905 70351		DIST 28904 70350		DKDT 28303 67217	
DN2012 27702 66066		DN2 27703 66067		DN2 27701 66065		DSCRIP 27699 66063	
LDU12 27658 66062		EDR12 27697 66061		EF12 27636 65764		EPSI 27637 65765	
EPSIT 27634 65763		EF12 27633 65761		ETA 27632 65760		FB 27630 65756	
FC 27625 65751		F12 27626 65754		F12 27627 65753		FH12 27565 65555	
FMALC 27564 65554		FPE 27504 65560		FPM2 27443 65463		FH 27625 65751	
FMS 27383 65367		F12 27323 65273		FKPSI 27321 65271		FLELIN 27260 65174	
FLELIN 27259 65173		FLEW 27256 65172		FLEW 27198 65076		FLNOP 27018 65612	
FLNC 27076 64706		FL2 26956 64516		FL 27261 65175		FMU12 26828 64314	
FMUL 26868 64410		FMU12 26827 64313		FPUT12 26767 64217		FNDSSL 26706 64122	
FNOREW 23215 55257		FNLEF 23216 55260		F5M12 23210 55252		F5H12 26044 62674	
F5M1 26644 64024		F5HF 26034 62662		F5F 26705 64121		F5KRB 26022 62646	
F5KRC 26012 62654		F5KRD 26002 62622		F5KRF 26001 62621		FSKRR 25999 62617	
F5K 26032 62661		F5M1 25989 62663		F5P12 25986 62602		FSMN 25988 62604	
F5MC 25966 62601		GAP 25964 62600		HE 25983 62577		IALT 25977 62571	
IDEL 25976 62570		INLCO 25975 62567		INDLAS 25965 62555		INDP 25955 62543	
INUPS 25553 62541		INDR 25503 62457		INDSTP 25902 62456		INDTYP 25900 62454	
IPRINT 23213 55255		JBYCTH 23211 55253		JANPLT 25890 62441		KS 25888 62440	
LP2 25686 62436		L 25687 62437		ACCUNT 23212 55254		NSR 25883 62433	
NS 25684 62434		LCIVER 25682 62432		CGIVEK 25881 62431		NSRIN 25810 62322	
PRAL 25870 62416		PRATIN 25749 62225		PRAT 25809 62321		PRDS 25688 62130	
PRF 25687 62127		PSITOL 25165 61115		PASAVE 25686 62126		PSCALC 25285 61305	
PSI 25225 61211		REN 23217 55261		REX 23218 55262		RESTAR 25162 61112	
RETFET 23219 55263		RHC 25161 61111		RHCSTG 25039 60717		RHOCAL 25101 61015	
RMS 25041 60721		R 25163 61113		RSC 24966 60632		RN 25038 60716	
SCHLIN 24584 60630		SCHTIN 24583 60627		SCL 24582 60626		RS 24987 60633	
SIGMAC 24861 60435		SIGMAH 24801 60341		SIGMAU 24741 60245		SHANGL 24862 60436	
STRLL 23206 55246		THF 23205 55251		TALN 24620 60054		STRLL 23207 55247	
THETAT 24499 57663		THF 24498 57662		TIN 24457 57661		TESTRA 24500 57664	
TITLE3 24472 57630		TM 24460 57614		T 24680 60150		TITLE2 24484 57644	
TVNO 24359 57517		TVD2 24397 57515		U12 24336 57420		TVNOP 24398 57516	
UINF 24274 57322		ULCLIP 24273 57321		UM1 24212 57224		UE 24275 57323	
U 24356 57514		US 24092 57034		WDT 24032 56740		UM 24272 57320	
XLS 23429 55605		XRN 23379 55523		X 23432 55610		XL 23430 55606	
Y12 23206 55250		YCALC 23316 55424		Y 23376 55520		XU12 23377 55521	
						YTH 23256 55330	

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YTHU 23245 55315 21R 23242 55312 21 23244 55314 21S 23232 55300
 ZZR 23230 55276 22 23231 55277 22S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

LOC	CCT	IFN	LCC	DEC	LOC	DEC	LOC
DELTA	2110 04104	15042	2110 04103	INDFSU	2114 04102	DEC	2113 04101
INDS	2111 04073	INDSC	2110 04076	INDS7	2109 04075	INDLR	2108 04074
LCRPI	2106 04072	K2	2105 04071	N	2104 04070	NSM1	2103 04067
SLOPE1	2101 04065	SLOPE2	2100 04064			SOELTP	2102 04066

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

LOC	CCT	IFN	LCC	DEC	LOC	DEC	LOC
B12	2045 04031	R15	5 04024	WIP	25 04022	EFN	500 04015
B12JT	2045 04005	B12MS	2761 04000	B12MD	2765 03777	B1FK	5000 03776
B14SA	5002 03765	B14SE	5003 03746			B14S8	5000 03776

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

LOC	CCT	DEC	LOC	DEC	LOC	DEC	LOC
11	2074 04032	21	1550 03706	31	2002 03722	41	32767 77777
C100	2065 04045	C101	2066 04046	C103	2067 04047	C105	2068 04050
C107	2068 04052	C108	2069 04053	C109	2070 04054	C110	2071 04055
C1106	2055 04057	C1107	2096 04060	C1109	2097 04061	C1200	2098 04062
C1245	1233 02321	C1246	1290 02412	C1345	1232 02320	D140M	353 00541
D1444	1225 02311	D1447	1461 02665	D144R	1472 02700	D1454	1507 02743
D1650	1667 03227	E10	342 00526	E10	363 00553	E112	460 00714
E117	456 00760	E119	522 01012	E11C	587 01113	E13D	993 01741
E150	1498 02732	E110F	368 00560	E113K	1067 02053	E114A	1289 02411
						E143P	1052 02034

LOCATIONS OF NAMES IN TRANSFER VECTOR

LOC	CCT	DEC	LOC	DEC	LOC	DEC	LOC
ATAN	10 00012	CELGE	12 00014	CUNPRG	7 00007	EXIT	23 00027
HSCLUT	10 00022	PRIEKN	11 00013	RACBLY	14 00016	SHORT	8 00010
STEPSZ	21 00025	LCSTRE	20 00024	UEDGE	16 00020	VISLAT	15 00017
(F11)	5 00005	(FPT)	0 00000	(RTN)	3 00003	(SCH)	22 00026
(SLU)	6 00006	(SPH)	15 00023	(STH)	4 00004	(TSH)	1 00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN	CELGE	CCNFRG	EXIT	EXP(3	HSCLUT	PRTERH	RA080Y	STAUT
STEPSZ	LCSTRE	UEDGE	VISLAT	WUGRT	(FIL)	(FPT)	(RTN)	(SLI)
(SLU)	(SPH)	(STH)	(TSH)					

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LCC	EFN	IFN	LCC	EFN	IFN	LCC
1	21 00044	9	70 00500	11	72 00507	13	75 00530	15
16	77 00542	17	80 00551	18	81 00555	19	82 00562	20
30	90 00640	32	94 00670	63	95 00673	65	96 00676	68
70	58 00707	75	99 00715	76	100 00723	78	102 00731	81
82	105 00745	84	107 00761	85	109 00777	87	111 01013	88
89	116 01043	90	120 01114	91	121 01121	92	122 01125	94

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99	126 C1145	100	128 C1152	175	129 01156	180	175 01223	210	185 01451
300	186 C1455	305	187 01457	310	188 01462	315	189 01464	325	190 C1470
335	191 C1474	345	192 C1500	355	193 C1504	365	194 01510	375	195 01514
400	196 C1520	510	197 C1523	520	213 01622	521	214 01626	523	216 01645
526	216 01662	540	219 01664	545	221 01672	550	222 01704	600	225 01715
640	226 C1717	650	227 01723	660	228 C1725	661	230 01742	662	231 01747
662	233 C1762	663	235 C1767	664	238 C2010	667	240 02022	668	241 02026
675	242 C2035	680	243 C2040	700	245 C2054	800	246 02056	1700	247 02067
1900	241 C2071	2000	245 02073	2005	251 C2104	2009	253 02123	2010	254 02161
2250	251 C2217	2300	257 C2254	2350	258 02257	2400	259 02262	2410	260 02266
2415	261 C2275	2416	264 C2326	2418	265 C2332	24164	266 02335	2417	267 02347
2418	265 C2415	2419	270 C2465	2420	272 02545	2424	274 02564	2425	275 02601
2428	277 C2623	2430	275 C2630	2431	280 02634	2500	281 02640	2501	283 02644
2502	284 C2651	2503	285 02657	2508	286 C2663	2510	287 02666	2518	288 02676
2520	289 C2701	2528	290 C2711	2529	291 C2715	2530	292 02717	2540	294 02737
2560	295 C2742	2563	296 C2744	2567	316 03044	2570	322 03071	2568	324 03100
2565	328 C3107	2572	327 C3115	2575	329 03124	2600	330 03126	2602	333 03144
2604	334 C3151	2608	335 C3166	2610	340 03167	2650	341 03174	2655	342 03205
2660	343 C3207	2665	347 C3245	2670	350 03256	2675	355 03311	2680	360 03334
2700	362 C3344	2750	365 03347	2755	364 03353	2760	365 03355	2763	371 03407
2775	420 C3626	2800	421 C3630	2900	423 03633	3000	427 03647	3020	428 03653
3030	429 C3657	3100	432 C3665	3150	437 03701				

SUBROUTINE CEDGE(J,NSTART,MEND)

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DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60),
B6T(60),B7T(60),B8T(60),B9T(60),B10T(60),B11T(60),B12T(60),
B13T(60),B14T(60),B15T(60),B16T(60),B17T(60),B18T(60),B19T(60),
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B160T(60),B161T(60),B162T(60),B163T(60),B164T(60),B165T(60),B166T(60),
B167T(60),B168T(60),B169T(60),B170T(60),B171T(60),B172T(60),B173T(60),
B174T(60),B175T(60),B176T(60),B177T(60),B178T(60),B179T(60),B180T(60),
B181T(60),B182T(60),B183T(60),B184T(60),B185T(60),B186T(60),B187T(60),
B188T(60),B189T(60),B190T(60),B191T(60),B192T(60),B193T(60),B194T(60),
B195T(60),B196T(60),B197T(60),B198T(60),B199T(60),B200T(60),B201T(60),
B202T(60),B203T(60),B204T(60),B205T(60),B206T(60),B207T(60),B208T(60),
B209T(60),B210T(60),B211T(60),B212T(60),B213T(60),B214T(60),B215T(60),
B216T(60),B217T(60),B218T(60),B219T(60),B220T(60),B221T(60),B222T(60),
B223T(60),B224T(60),B225T(60),B226T(60),B227T(60),B228T(60),B229T(60),
B230T(60),B231T(60),B232T(60),B233T(60),B234T(60),B235T(60),B236T(60),
B237T(60),B238T(60),B239T(60),B240T(60),B241T(60),B242T(60),B243T(60),
B244T(60),B245T(60),B246T(60),B247T(60),B248T(60),B249T(60),B250T(60),
B251T(60),B252T(60),B253T(60),B254T(60),B255T(60),B256T(60),B257T(60),
B258T(60),B259T(60),B260T(60),B261T(60),B262T(60),B263T(60),B264T(60),
B265T(60),B266T(60),B267T(60),B268T(60),B269T(60),B270T(60),B271T(60),
B272T(60),B273T(60),B274T(60),B275T(60),B276T(60),B277T(60),B278T(60),
B279T(60),B280T(60),B281T(60),B282T(60),B283T(60),B284T(60),B285T(60),
B286T(60),B287T(60),B288T(60),B289T(60),B290T(60),B291T(60),B292T(60),
B293T(60),B294T(60),B295T(60),B296T(60),B297T(60),B298T(60),B299T(60),
B300T(60),B301T(60),B302T(60),B303T(60),B304T(60),B305T(60),B306T(60),
B307T(60),B308T(60),B309T(60),B310T(60),B311T(60),B312T(60),B313T(60),
B314T(60),B315T(60),B316T(60),B317T(60),B318T(60),B319T(60),B320T(60),
B321T(60),B322T(60),B323T(60),B324T(60),B325T(60),B326T(60),B327T(60),
B328T(60),B329T(60),B330T(60),B331T(60),B332T(60),B333T(60),B334T(60),
B335T(60),B336T(60),B337T(60),B338T(60),B339T(60),B340T(60),B341T(60),
B342T(60),B343T(60),B344T(60),B345T(60),B346T(60),B347T(60),B348T(60),
B349T(60),B350T(60),B351T(60),B352T(60),B353T(60),B354T(60),B355T(60),
B356T(60),B357T(60),B358T(60),B359T(60),B360T(60),B361T(60),B362T(60),
B363T(60),B364T(60),B365T(60),B366T(60),B367T(60),B368T(60),B369T(60),
B370T(60),B371T(60),B372T(60),B373T(60),B374T(60),B375T(60),B376T(60),
B377T(60),B378T(60),B379T(60),B380T(60),B381T(60),B382T(60),B383T(60),
B384T(60),B385T(60),B386T(60),B387T(60),B388T(60),B389T(60),B390T(60),
B391T(60),B392T(60),B393T(60),B394T(60),B395T(60),B396T(60),B397T(60),
B398T(60),B399T(60),B400T(60),B401T(60),B402T(60),B403T(60),B404T(60),
B405T(60),B406T(60),B407T(60),B408T(60),B409T(60),B410T(60),B411T(60),
B412T(60),B413T(60),B414T(60),B415T(60),B416T(60),B417T(60),B418T(60),
B419T(60),B420T(60),B421T(60),B422T(60),B423T(60),B424T(60),B425T(60),
B426T(60),B427T(60),B428T(60),B429T(60),B430T(60),B431T(60),B432T(60),
B433T(60),B434T(60),B435T(60),B436T(60),B437T(60),B438T(60),B439T(60),
B440T(60),B441T(60),B442T(60),B443T(60),B444T(60),B445T(60),B446T(60),
B447T(60),B448T(60),B449T(60),B450T(60),B451T(60),B452T(60),B453T(60),
B454T(60),B455T(60),B456T(60),B457T(60),B458T(60
```

DIMENSION ROOTT(60)

CEGE(1) IS CHALL
CEGE 9 IS EQUILIB

```
J=J
NSTART=NSTART
NEND=NEND
IF(J-9) 40,1000,1000
40 SUMCW=0.0
IF(J-1) 79,50.80
50 00 55 I=1,6
```

PAGE 2

```

SUBROUTINE CEDGE(J,NSTART,MEND)
1XRN=0
55 CM(1,I)=CC(1,I)+CC(2,I)*XRN+CC(3,I)*XRN+2*CC(4,I)*XRN+3*CC(5,I)*
   XRN+4
   CM(1,7)=FM(7)/FM(6)*CM(1,6)
   DO 52 I=1,NS
   IF(CM(1,I)) 70,60,60
60 IF(CM(1,I)-1.0) 62,62,70
62 CONTINUE
63 DO 65 I=1,NS
65 SUMCW=SUMCW+CM(1,I)
   IF(SUMCW-1.001) 67,78,70
67 IF(SUMCW-.999) 70,78,78
70 PRINT 72,(CM(1,I),I=1,NS),SUMCW
   STOP 71
72 FORMAT(4E13.4/4E13.4)
78 RETURN
79 STOP 60
80 IF(J-3) 90,200,300
90 DO 100 I=1,NS
100 CM(L,I)=WDT(L,I)*DELTA/RHO(L)/U(L)*C(L,I)
   RETURN
200 DO 250 I=1,NS
250 CM(L+1,I)=WDT(L+1,I)*DELTA/RHO(L+1)/U(L+1)*C(L+1,I)
300 DO 350 I=1,NS
350 CM(L+2,I)=WDT(L+2,I)*DELTA/RHO(L+2)/U(L+2)*C(L+2,I)
   RETURN
1000 DO 1150 I=NSTART,MEND
   ROOTT(1)=SQRT(T(1))
   B1=1.+66667*EXP(-11390.772/T(1))+EXP(-18984.62/T(1))/3.
   B4=1.+6*EXP(-228./T(1))+2*EXP(-328./T(1))
   E4=1.+EXP(-178./T(1))
   B5=1.+2.5*EXP(-27698.424/T(1))+1.5*EXP(-41520.32/T(1))
   E1=1.-EXP(-2274./T(1))
   E2=1.-EXP(-3395./T(1))
   E3=1.-EXP(-2740./T(1))
   SF1=908.1869*ROOTT(1)*T(1)*T(1)*B1/E1
   SF2=178.3938*ROOTT(1)*T(1)*T(1)/E2
   SF3=934.13519*ROOTT(1)*T(1)*T(1)*E4*EXP(-11062.98/T(1))/E3
   SF4=2237.1532*T(1)*ROOTT(1)*B4*EXP(-29501.28/T(1))
   SF5=1461.9321*T(1)*ROOTT(1)*B5*EXP(-56544.12/T(1))
   SF6=SQRT(SF4*SF5)
   BBAR=0.0
   DO 1130 M=1,20
   BTERM=SF4*1.E-6+BBAR*SF3*1.E-12
   AC=SF1*RHO(1)*1338.7286E-12
   ABAR=(-BTERM+SQRT(BTERM*BTERM+AC))/(SF1*4.E-12)
   BTERM=SF5*1.E-6+ABAR*SF3*1.E-12
   AC=SF2*RHO(1)*5060.8386E-12
   BBAR1=(-BTERM+SQRT(BTERM*BTERM+AC))/(4.E-12*SF2)
   IF(ABS(BBAR1-BBAR)-.00001) 1120,1130,1130
1130 BBAR=BBAR1
   PRINT 1300
1300 FORMAT(4G14ALPHA BAR AND BETA BAR DID NOT CONVERGE)
   CALL EXIT
1120 BBAR=BBAR1
   CM(1,1)=SF1*ABAR*ABAR*2.77278E-15/RHO(1)
   CM(1,3)=SF2*BBAR*BBAR*2.428056E-15/RHO(1)

```

PAGE 3

SUBROUTINE CEDGE(J,NSTART,MEND)

```
CM(I,51)=SF3*ABAR*BAR*2.600418E-15/RHO(I)
CM(I,21)=SF4*ABAR*1.38639E-9/RHO(I)
CM(I,41)=SF5*BAR*1.214028E-9/RHO(I)
E12=EXP((-32125.131/T(I)))
Q=-.15966227E-11*Y(I)*E12/E2/B4
ENOP=SQRTF(Q)*SQRTF(CM(I,2))*SQRTF(CM(I,4))
CM(I,61)=ENOP*233.902493
CM(I,71)=ENOP/233.902493
1150 CONTINUE
      RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)
```

SUBROUTINE CEDGE(J,NSTART,NEND)

STORAGE NOT USED BY PROGRAM

DEC OCT
725 01325

DEC OCT
23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

[illegible]

SUBROUTINE CEDGE(J,N,START,END)

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC	LOC	DEC	LOC	DEC	LOC
724	01324				

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	LOC	DEC	LOC	DEC	LOC
664	01230	AC	663	01227	
659	01223	BBAR	658	01222	
654	01216	E3	653	01215	
649	01211	Q	648	01210	
644	01204	SF5	643	01203	

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC
72	01161				
810K	1300	01156			

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	LOC	DEC	LOC	DEC	LOC
626	01162	2)	561	01061	
634	01172	C100	635	01173	
639	01177	C1204	640	01200	
464	00720	E112	472	00730	

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	LOC	EXP	DEC	LOC	DEC	LOC
4	00004		3	00003		
					2	00002
					1	00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP	LOC	EXP	LOC	EXP	LOC
4	00004				

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	LOC	EFN	LOC	EFN	LOC
17	00051	50	19	00060	
26	00157	65	27	00164	
38	00232	80	39	00234	
45	00270	300	46	00302	
77	00741	1150	88	01052	

EFN	LOC	EFN	LOC	EFN	LOC
25	00154	62	25	00154	
36	00226	78	36	00226	
44	00262	200	44	00262	
74	00724	1130	74	00724	

PAGE 1

SUBROUTINE COMPRG(K)

SUBROUTINE COMPRG(K)

```

COMMON AIL,A11,A2,A3L,A3T,A4L,A4T,A5L,A5T,A6T,A6T,A82T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AM12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B9T,B0T,004T,005T,006T,007T,008T,009T,010T,011T,012T,
3BLOCK,BSR,BUL2,C,C12,CC,CCALC,CE,CM,CW1,CM2,CONEAN,CP,CPE,CS,
4CSR,DCDP12,DEL,DELTA,DELXOD,DELXST,DMDP12,DIST,DKDL,
5DKDT,DN2,DN2D02,DN2D02,DSCRIP,DUDP12,EDENS,EPSI,
6EPSIC,EPSIM,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
7FEBC,FM,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FIMO,FK,FKPSI,FL,FLELIN,FLELM,FLEWL,FLEWT,
1FLN2,FLNO,FLNOP,FLQ2,FM,FMUL,FMUL12,FMUTIM,FMUTIP,FNDSSM,
2FNDSSL,FMS,FMSHE,FSHI,FSM12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMNO,FSMNP,FSMO,GAMM,HE,
4HH,IALT,IDEL,INDCOG,INDLAS,INDP,INDPRI,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6OGIVEM,OGIVEK,P,PE,PR,PRAL,PRALIM,PRAT,PRATIM,PROIRA
COMMON PRD,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RMO,
1RHOCAL,RHDE,RHOL2,RHOSTG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCI,SWANGL,SIGMAC,SIGMAH,SIGMAU,
3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVNO,TVNOP,TVO2,U,UI2,UCALC,UE,UINF,ULOLIM,UM,UMI,
6UM2,US,WGOT,X,XI,XL,XLS,XRN,XS,XUL2,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REN,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSM12,I12,Y12,STRLL,STRUL,RHOL2,AAU,EMP,FSK15,
2FSM015,FSMN15,FSME5

```

```

DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),BC12(10),BLOCK(60),BSR(10),C(60,10),C12(10),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLNO(60),
6FLNOP(60),FLO2(60),FM(10),FMUL(60),FMUTIM(60)
DIMENSION FMUTIP(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
1FSKR8(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UMI(60),UM2(60),US(60),
1UDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

```

K=K

IF(K-9) 100,3000,3000

100 IF(K-2) 120,600,2200

C PROGRAM CONSTANTS FOR MOMENTUM EQUATION

120 CP=14000.

D02=5.1155

DN2=9.7592

DNO=6.5060

DN2D02=.5*(DN2+D02)-DNO

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SUBROUTINE CONPRG(K)

```

FINO=9.258
FM(1)=32.000
FM(2)=16.000
FM(3)=28.016
FM(4)=14.008
FM(5)=30.008
FM(6)=30.008
FM(7)=5.4862E-4
FSMO=2.6556E-23
FSMN=2.3249E-23
FSMNO=4.9805E-23
FSME=9.1056E-28
FSMNOF=FSMNO-FSME
R=8.95805E4
TVN2=3395.0
TVNO=2740.0
TVNOP=3395.0
TV02=.274.0

```

PROGRAM CONSTANTS FOR SPECIES EQUATION

```

140 ETA=6.0251E23
FSHP=4.8247E-34
FSK=1.01794E-23
FSKRE=2.7E-11
EHP=ETA*FSHP
FSK15=FSK*.1.5/FSHP
FSM015=FSMNO*.1.5/FSHP
FSM15=FSMN*.1.5/FSHP
FSME3=SQRTF(FSME1/FSHP)

```

SCHMIDT AND DIFFUSION COEF RATIOS FOR SPECIES EQS

```

DO 145 N=1,60
SCL(N)=SCHLIN
SCT(N)=SCHTIN
DKOL(N,1)=1.0
DKOL(N,2)=1.0
DKOL(N,3)=1.0
DKOL(N,4)=1.0
DKOL(N,5)=1.0
DKOL(N,6)=1.0
DKOL(N,7)=1.0
DKOT(N,1)=1.0
DKOT(N,2)=1.0
DKOT(N,3)=1.0
DKOT(N,4)=1.0
DKOT(N,5)=1.0
DKOT(N,6)=1.0
DKOT(N,7)=1.0

```

PRANDTL AND LEWIS NOS FOR ENERGY EQ

```

PRAL(N)=PRALIN
PRAT(N)=PRATIN
FLEW(N)=FLELIN
145 FLENT(N)=FLETIN
RETURN
END FN=L

```


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```

SUBROUTINE COMPRG(N)
  RHOCAL(1)=RHO(1)
  PSI(1)=0.0
  DO 700 N=2,L
    PSI(N)=PSI(N-1)+.5*(Y(N)-Y(N-1))*RS*(RHO(N)+U(N)+RHO(N-1)+U(N-1))
    DELTAP=(PSI(L)-PSI(1))/(FN-1.0)
    DO 800 N=1,LP2
      WRITE OUTPUT TAPE 4,750,N,PSI(N)
    750 FORMAT(5X13,3X1P13.5)
    FN=FN+1
    800 PSCALC(N)=(FN-1.0)*DELTAP
    910 J=2
    920 DO 1400 N=2,L
      950 IF(PSCALC(N)-PSI(J))1300,1200,1000
      1000 J=J+1
      IF(J-L)950,950,1010
    1010 J=J-1
    1200 UCALC(N)=U(J)
    DO 1250 I=1,NS
      CCALC(N,I)=C(J,I)
      FHCALC(N)=FH(J)
      RHOCAL(N)=RHO(J)
    GO TO 1400
    1300 PFACR=(PSCALC(N)-PSI(J-1))/(PSI(J)-PSI(J-1))
      UCALC(N)=U(J-1)+PFACR*(U(J)-U(J-1))
      DO 1310 I=1,NS
        CCALC(N,I)=C(J-1,I)+PFACR*(C(J,I)-C(J-1,I))
        FHCALC(N)=FH(J-1)+PFACR*(FH(J)-FH(J-1))
        RHOCAL(N)=RHO(J-1)+PFACR*(RHO(J)-RHO(J-1))
    1400 CONTINUE
      UCALC(L+1)=UCALC(L)
      UCALC(L+2)=UCALC(L)
      DO 1450 I=1,NS
        CCALC(L+1,I)=CCALC(L,I)
        CCALC(L+2,I)=CCALC(L,I)
        FHCALC(L+1)=FHCALC(L)
        FHCALC(L+2)=FHCALC(L)
        RHOCAL(L+1)=RHOCAL(L)
        RHOCAL(L+2)=RHOCAL(L)
      YCALC(1)=0.0
    1470 DEL12=SQRT(DELTAP)
      DELN12=.707107*DEL12
      AU12=(2.0*UCALC(2)-UCALC(3))/(.58579/DEL12)
      BU12=(UCALC(3)-1.41421*UCALC(2))/(.58579/DEL12)
      U12=AU12*DELN12+BU12*.5*DELTAP
      DU0P12=.5*AU12/DELN12+BU12
      AAU=(2.0*RHOAL(2)+UCALC(2)-RHOCAL(3)+UCALC(3))/DEL12+.58579
      ABU=(RHOCAL(3)+UCALC(3)-1.41421*RHOAL(2)+UCALC(2))/DEL12+.58579
      YCALC(2)=2.0/ABU/RS*LOGF(1.0+ABU/AAU*DEL12)
      PRINT 1510,RHOCAL(2),RHOCAL(3),RS,DELTAP,UCALC(2),UCALC(3),DU0P12
    1,AAU,ABU,YCALC(2),U12
    1510 FORMAT(3X1P6E13,5/8X1P5E13.5)
    1650 DO 1900 N=3,LP2
      1900 YCALC(N)=YCALC(N-1)+.5*(PSCALC(N)-PSCALC(N-1))/RS*(1.0/(RHOCAL(N)+
        UCALC(N))+1.0/(RHOCAL(N-1)+UCALC(N-1)))
        IF(ABS(YCALC(L)-Y(L))/Y(L))-.001) 1910,1910,1905
    1905 PRINT 1906, YCALC(L),Y(L)

```


SUBROUTINE CONPRG(K)

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STORAGE NOT USED BY PROGRAM

DEC OCT
800 11440

DEC OCT
23190 55236

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

ALL 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455	DELX00 28907 70353
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	AAU 23204 55244	DELX01 28908 70354
AE1T 32552 77450	AE1T 32551 77447	AB1T 32547 77443	AB1T 32546 77442	ABST 32548 77444	DELX02 28909 70355
ASR 32533 77425	AU12 32523 77413	AC12 32545 77441	AC12 32542 77412	ALPHA 32534 77426	DELX03 28910 70356
B4T 32342 77126	B5T 32282 77032	R6T 32222 76736	B7T 32162 76642	B3T 32402 77222	DELX04 28911 70357
B8T 32101 76545	B8T 32100 76544	B8T 32099 76543	B8T 32098 76542	B8T 32102 76546	DELX05 28912 70358
B8T 32096 76540	BC12 32095 76537	BH12 32085 76525	BLOCK 32084 76524	B8T 32097 76541	DELX06 28913 70359
BUI2 32014 76416	C12 31413 75265	CCALC 31353 75171	CC 31403 75253	B8T 32098 76542	DELX07 28914 70360
CM1 30143 72677	CM2 30133 72665	CM 30743 74027	CONCAN 29533 71535	B8T 32099 76543	DELX08 28915 70361
CP 29532 71534	C 32013 76415	CSR 28930 70472	CS 29530 71532	B8T 32100 76544	DELX09 28916 70362
DCLP12 28920 70370	DEL 28910 70356	DELTA 28909 70355	DELTA 28908 70354	B8T 32101 76545	DELX10 28917 70363
DELX01 28906 70352	DHDP12 28905 70351	DIST 28904 70350	DKUL 28903 70347	B8T 32102 76546	DELX11 28918 70364
DN2002 27702 66066	DN2 27703 66067	DN2 27701 66065	DO2 27700 66064	B8T 32103 76547	DELX12 28919 70365
DUP12 27698 66062	EDENS 27697 66061	EMP 23203 55243	EPSIC 27636 65764	B8T 32104 76548	DELX13 28920 70366
EPSI 27637 65765	EPSIT 27634 65762	EPSTU 27633 65761	ETA 27632 65760	B8T 32105 76549	DELX14 28921 70367
FR 27630 65756	FC 27629 65755	FEDA 27628 65754	FEDB 27627 65753	B8T 32106 76550	DELX15 28922 70368
FH12 27565 65655	FHCALC 27564 65654	FHE 27504 65560	FHM2 27443 65463	B8T 32107 76551	DELX16 28923 70369
FH 27625 65751	FHS 27383 65367	FIND 27323 65273	FKPSI 27321 65271	B8T 32108 76552	DELX17 28924 70370
FLELIN 27260 65174	FLELIN 27259 65173	FLEWL 27258 65172	FLEWT 27198 65076	B8T 32109 76553	DELX18 28925 70371
FLN0P 27018 64612	FLND 27078 64706	FLO2 26958 64516	FL 27261 65175	B8T 32110 76554	DELX19 28926 70372
FMUL12 26828 64314	FMUL 26808 64410	FMUTIM 26827 64313	FMUTIP 26767 64217	B8T 32111 76555	DELX20 28927 70373
FNDSSL 26706 64122	FNUREW 23215 55257	FNUREX 23216 55260	FSM12 23210 55252	B8T 32112 76556	DELX21 28928 70374
FSH12 26044 62674	FSHI 26644 64024	FSHP 26034 62662	FSM 26705 64121	B8T 32113 76557	DELX22 28929 70375
FSKRA 26032 62660	FSKRB 26022 62646	FSKRC 26012 62634	FSKRD 26002 62622	B8T 32114 76558	DELX23 28930 70376
FSKRF 26000 62620	FSKRK 25999 62617	FSK 26033 62661	FSME5 23199 55237	B8T 32115 76559	DELX24 28931 70377
FSM15 23200 55240	FSMOP 25986 62602	FSMND 25987 62603	FSMN 25988 62604	B8T 32116 76560	DELX25 28932 70378
FSMD 25985 62601	GAMM 25984 62600	HE 25983 62577	HH 25982 62576	B8T 32117 76561	DELX26 28933 70379
IDEL 25976 62570	IMDC00 25975 62567	INDLAS 25965 62555	INDPRI 25954 62542	B8T 32118 76562	DELX27 28934 70380
INDPS 25953 62541	INDR 25903 62457	INDSTP 25902 62456	INDSTR 25901 62455	B8T 32119 76563	DELX28 28935 70381
IPRINT 23213 55255	JBYCTR 23211 55253	JINPOT 25890 62442	JS 25889 62441	B8T 32120 76564	DELX29 28936 70382
LP2 25886 62436	L 25887 62437	NCOUNT 23212 55254	NPSI 25885 62435	B8T 32121 76565	DELX30 28937 70383
NS 25884 62434	OGIVEN 25882 62432	OGIVER 25881 62431	PE 25872 62420	B8T 32122 76566	DELX31 28938 70384
PRAL 25870 62416	PRATIN 25749 62325	PRAT 25809 62321	PROIRA 25748 62224	B8T 32123 76567	DELX32 28939 70385
PRP 25687 62127	PSITCU 25165 61115	PRSAVE 25686 62126	P 25880 62430	B8T 32124 76568	DELX33 28940 70386
PSI 25225 61211	REW 23217 55261	PS 25685 62125	QW 25164 61114	B8T 32125 76569	DELX34 28941 70387
RETHET 23219 55263	RHO 25161 61111	RHO2 23218 55262	RHO12 25040 60720	B8T 32126 76570	DELX35 28942 70388
RMOE 25041 60721	R 25163 61113	RSC 24986 60632	RMOU12 23203 55245	B8T 32127 76571	DELX36 28943 70389
RNS 25037 60715	SCHTIN 24983 60627	SCL 24982 60626	RSM 24985 60631	B8T 32128 76572	DELX37 28944 70390
SCHLIN 24984 60630	SIGMAH 24801 60341	SIGMA 24741 60245	SCT 24922 60532	B8T 32129 76573	DELX38 28945 70391
SIGMAC 24861 60435	T12 23209 55251	TAUM 24620 60054	STADIS 24681 60151	B8T 32130 76574	DELX39 28946 70392
SIRUL 23206 55246	THPLR 24498 57662	TIN 24497 57661	TAUP 24560 57760	B8T 32131 76575	DELX40 28947 70393
THETAT 24499 57663	TM 24460 57614	T 24680 60150	TITLE1 24496 57660	B8T 32132 76576	DELX41 28948 70394
TITLE3 24472 57630	TVO2 24397 57515	U12 24336 57420	TVM2 24400 57520	B8T 32133 76577	DELX42 28949 70395
TVND 24399 57517	ULOI 24274 57322	UM1 24212 57224	UUCALC 24335 57417	B8T 32134 76578	DELX43 28950 70396
UINF 24274 57322	US 24092 57034	WDT 24032 56740	UK2 24152 57130	B8T 32135 76579	DELX44 28951 70397
U 24396 57514	XRN 23379 55523	X 23432 56510	XL 23431 55607	B8T 32136 76580	DELX45 28952 70398
XLS 23429 55605			XU12 23377 55521	B8T 32137 76581	DELX46 28953 70399
				B8T 32138 76582	DELX47 28954 70400
				B8T 32139 76583	DELX48 28955 70401
				B8T 32140 76584	DELX49 28956 70402
				B8T 32141 76585	DELX50 28957 70403
				B8T 32142 76586	DELX51 28958 70404
				B8T 32143 76587	DELX52 28959 70405
				B8T 32144 76588	DELX53 28960 70406
				B8T 32145 76589	DELX54 28961 70407
				B8T 32146 76590	DELX55 28962 70408
				B8T 32147 76591	DELX56 28963 70409
				B8T 32148 76592	DELX57 28964 70410
				B8T 32149 76593	DELX58 28965 70411
				B8T 32150 76594	DELX59 28966 70412
				B8T 32151 76595	DELX60 28967 70413
				B8T 32152 76596	DELX61 28968 70414
				B8T 32153 76597	DELX62 28969 70415
				B8T 32154 76598	DELX63 28970 70416
				B8T 32155 76599	DELX64 28971 70417
				B8T 32156 76600	DELX65 28972 70418
				B8T 32157 76601	DELX66 28973 70419
				B8T 32158 76602	DELX67 28974 70420
				B8T 32159 76603	DELX68 28975 70421
				B8T 32160 76604	DELX69 28976 70422
				B8T 32161 76605	DELX70 28977 70423
				B8T 32162 76606	DELX71 28978 70424
				B8T 32163 76607	DELX72 28979 70425
				B8T 32164 76608	DELX73 28980 70426
				B8T 32165 76609	DELX74 28981 70427
				B8T 32166 76610	DELX75 28982 70428
				B8T 32167 76611	DELX76 28983 70429
				B8T 32168 76612	DELX77 28984 70430
				B8T 32169 76613	DELX78 28985 70431
				B8T 32170 76614	DELX79 28986 70432
				B8T 32171 76615	DELX80 28987 70433
				B8T 32172 76616	DELX81 28988 70434
				B8T 32173 76617	DELX82 28989 70435
				B8T 32174 76618	DELX83 28990 70436
				B8T 32175 76619	DELX84 28991 70437
				B8T 32176 76620	DELX85 28992 70438
				B8T 32177 76621	DELX86 28993 70439
				B8T 32178 76622	DELX87 28994 70440
				B8T 32179 76623	DELX88 28995 70441
				B8T 32180 76624	DELX89 28996 70442
				B8T 32181 76625	DELX90 28997 70443
				B8T 32182 76626	DELX91 28998 70444
				B8T 32183 76627	DELX92 28999 70445
				B8T 32184 76628	DELX93 29000 70446
				B8T 32185 76629	DELX94 29001 70447
				B8T 32186 76630	DELX95 29002 70448
				B8T 32187 76631	DELX96 29003 70449
				B8T 32188 76632	DELX97 29004 70450
				B8T 32189 76633	DELX98 29005 70451
				B8T 32190 76634	DELX99 29006 70452
				B8T 32191 76635	DELX100 29007 70453
				B8T 32192 76636	DELX101 29008 70454
				B8T 32193 76637	DELX102 29009 70455
				B8T 32194 76638	DELX103 29010 70456
				B8T 32195 76639	DELX104 29011 70457
				B8T 32196 76640	DELX105 29012 70458
				B8T 32197 76641	DELX106 29013 70459
				B8T 32198 76642	DELX107 29014 70460
				B8T 32199 76643	DELX108 29015 70461
				B8T 32200 76644	DELX109 29016 70462
				B8T 32201 76645	DELX110 29017 70463
				B8T 32202 76646	DELX111 29018 70464
				B8T 32203 76647	DELX112 29019 70465
				B8T 32204 76648	DELX113 29020 70466
				B8T 32205 76649	DELX114 29021 70467
				B8T 32206 76650	DELX115 29022 70468
				B8T 32207 76651	DELX116 29023 70469
				B8T 32208 76652	DELX117 29024 70470
				B8T 32209 76653	DELX118 29025 70471
				B8T 32210 76654	DELX119 29026 70472
				B8T 32211 76655	DELX120 29027 70473
				B8T 32212 76656	DELX121 29028 70474
				B8T 32213 76657	DELX122 29029 70475
				B8T 32214 76658	DELX123 29030 70476
				B8T 32215 76659	DELX124 29031 70477
				B8T 32216 76660	DELX125 29032 70478
				B8T 32217 76661	DELX126 29033 70479
				B8T 32218 76662	DELX127 29034 70480
				B8T 32219 76663	DELX128 29035 70481
				B8T 32220 76664	DELX129 29036 70482
				B8T 32221 76665	DELX130 29037 70483
				B8T 32222 76666	DELX131 29038 70484
				B8T 32223 76667	DELX132 29039 70485
				B8T 32224 76668	DELX133 29040 70486
				B8T 32225 76669	DELX134 29041 70487
				B8T 32226 76670	DELX135 29042 70488
				B8T 32227 76671	DELX136 29043 70489
				B8T 32228 76672	DELX137 29044 70490
				B8T 32229 76673	DELX138 29045 70491
				B8T 32230 76674	DELX139 29046 70492
				B8T 32231 76675	DELX140 29047 70493
				B8T 32232 76676	DELX141 29048 70494
				B8T 32233 76677	DELX142 29049 70495
				B8T 32234 76678	DELX143 29050 70496
				B8T 32235 76679	DELX144 29051 70497
				B8T 32236 76680	DELX145 29052 70498
				B8T 32237 76681	DELX146 29053 70499
				B8T 32238 76682	DELX147 29054 70500

SUBROUTINE CONPRG(K)

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Y12 23208 55250 YCALC 23316 55424 Y 23376 55520 YTHC 23255 55327 YTH 23256 55330
YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC OCT DEC OCT DEC OCT DEC OCT DEC OCT
BRU 799 01437 DEL12 798 01436 DELH12 797 01435 FN 796 01434 J 795 01433
LP1MN 794 01432 LP2MN 793 01431 N 792 01430 PFACTR 791 01427 SUMDP 790 01426

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN LOC EFN LOC EFN LOC EFN LOC EFN LOC
8)NE 750 01405 8)IF6 1510 01402 8)IR1 1906 01376

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC OCT DEC OCT DEC OCT DEC OCT DEC OCT DEC OCT
1) 774 01406 2) 715 01313 3) 721 01321 6) 754 01362 C)G1 761 01415
C)G2 782 01416 C)G3 783 01417 C)G4 784 01420 C)G5 785 01421 C)I01 786 01422
C)I02 787 01423 C)I03 788 01424 C)I04 789 01425 C)I05 649 01211 D)I21L 692 01264
D)I06A 257 00401 D)I07 312 00470 D)I08 341 00525 D)I09 710 01306 D)I60A 256 00400
D)I60J 340 00524 D)I61M 709 01305 E)I5 162 00242 E)I6 259 00403 E)I8 266 00412
E)I9 296 00450 E)I17 610 01142 E)I1H 680 01250 E)I1J 607 01257 E)I19 620 01154
E)I318 616 01150

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC OCT LOG DEC OCT LOG DEC OCT LOG DEC OCT LOG
EXP(3 0 00000 LOG 4 00004 SORT 1 00001 (FIL) 3 00003 DEC OCT
(STH) 2 00002

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3 LOG SORT (FIL) (SPH) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN IFN LOC EFN IFN LOC EFN IFN LOC EFN IFN LOC EFN IFN LOC
100 15 00033 120 16 00037 140 39 00123 145 68 00231 600 71 00243
700 75 00257 800 81 00334 910 82 00344 220 83 00350 950 84 00404
1000 85 00413 1010 87 00424 1200 88 00431 1250 90 00434 1300 94 00451
1310 97 00471 1400 100 00526 1450 105 00550 1470 111 00567 1450 122 00724
1900 123 00727 1905 125 00771 1910 127 01000 2000 134 01026 2200 135 01036
2300 139 01064 2310 147 01103 2500 154 01121 3000 157 01132 3001 158 01135
3005 159 01143 3009 160 01151 3101 162 01155 3109 166 01203 3111 167 01210
3115 168 01212 3119 170 01215 3201 172 01233 3209 174 01260 3211 175 01263
3215 176 01265 3301 177 01307

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SUBROUTINE HSOLUT

SUBROUTINE HSOLUT

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COMMON AIL,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,ABIT,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B82T,B83T,B84T,B85T,B86T,B87T,B88T,B89T,
3BL0CK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
4CSR,DCOP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5OKDT,ON2,ON2002,ONG,002,OSCRIP,OU0P12,EDENS,EPSI,
6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,F8,FC,FEDA,FE08,
7FE0C,FEH,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FINQ,FK,FKPSI,FL,FLELIN,FLEW,FLEWT,
1FLN2,FLN0,FLN0P,FL02,FM,FML,FML12,FMLTIP,FNDSSH,
2FN0SSL,FSH,FSHE,FSHI,FSH12,FSHP,FSK,FSKRA,FSKR8,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMN0,FSMN0P,FSM0,GAMM,HE,
4HH,IALT,IOEL,INDC00,INOLAS,INDP,INOPRI,INDPS,INDR,
5INOSTP,INOSTR,(NOTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6GIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RH0,
1RH0CAL,RH0E,RH012,RH0STG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCT,SHANGL,SIGMAH,SIGMAU,
3STA0IS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVN0,TVN0P,TV02,U,U12,UCALC,UE,UINF,USOLIM,UM,UM1,
6UM2,US,WOOT,X,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSH12,I12,Y12,STRLL,STRUL,RH0U12,AAU

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DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8T(60),B82T(60),B83T(60),B84T(60),B85T(60),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSK(10),DCOP12(10),OKDL(60,10),DKDT(60,10),
4E0ENS(60),FHI(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPS(60),FLEWL(60),FLEWT(60),FLN2(60),FLN0(60),
6FLN0P(60),FL02(60),FM(10),FML(60),FMLTIP(60),
DIMENSION FMUTIP(60),FSH(60),FSHI(60,10),FSH12(10),FSKRA(10),
1FSKR8(10),FSKRC(10),FSKRK(10),HH(5),INOC00(10),
2INOLAS(10),INOPS(50),IND(50),P(8),PROIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSI(60),RH0(60),
4RH0CAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(50),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1W00T(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

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2500 FHM(1)=HH(1)+XRN*(HH(2)+XRN*(HH(3)+XRN*(HH(4)+HH(5)+XRN)))
2505 D0 2550 N=2,L
SUMHL=0.0
SUMHT=0.0
SUMHPL=0.0
SUMHPT=0.0
IF(N-2) 2508,2508,2520
2508 UAVGI=RS*(RH012*U12+U12*DU0P12+RH0(2)*U(2)+U(2)*(U(2)+U(3))+.5-U12
1)/OELTAP)
UAVG2=.5*RS/OELTAP*((RH0(3)+U(3)+U(3)+RH0(2)+U(2)+U(2))*(U(3)-U(2)

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SUBROUTINE HSOLUT

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STORAGE NOT USED BY PROGRAM

OEC OCT
809 01451
OEC OCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

ALL 32561 77461	A3L 32558 77456	A3T 32557 77455
A4L 32556 77454	A5T 32553 77451	AAU 23204 55244
AB1T 32552 77450	AB4T 32549 77445	AB5T 32548 77444
AB6T 32547 77443	AM12 32535 77427	ALPHA 32534 77426
ASR 32533 77425	B2T 32462 77316	B3T 32402 77222
B4T 32342 77126	B7T 32162 76642	B81T 32102 76546
B82T 32101 76545	B85T 32098 76542	B86T 32097 76541
B87T 32096 76540	BLOCK 32084 76524	B8R 32024 76430
BUI2 32014 76416	CC 31403 75253	CE 30753 74041
CM1 30143 72677	CCNEAN 29533 71535	CPE 29531 71533
CP 29532 71534	CS 29530 71532	CSUB 23214 55256
OCOP12 28920 70370	DELTA 28908 70354	DELX0D 28907 70353
DELXST 28906 70352	DKDL 28903 70347	DKDT 28303 67217
ON2D02 27702 66066	D02 27700 66064	DSCRIP 27699 66063
OUOP12 27698 66062	EPSIH 27635 65763	EPSI 27637 65765
EPSIT 27634 65762	FA 27631 65757	FB 27630 65756
FC 27629 65755	FEDC 27626 65752	FH12 27565 65655
FHCALC 27564 65654	FHM 27503 65557	FH 27625 65751
FHS 27383 65367	FK 27322 65272	FLELIN 27260 65174
FLETIN 27259 65173	FLN2 27138 65002	FLN0P 27018 64612
FLN0 27078 64706	FM 26898 64422	FMDL12 26828 64314
FMUL 26818 64410	FNDSSH 26707 64123	FNDSSL 26706 64122
FNUREW 23215 55257	FSHE 26645 64025	FSH112 26044 62674
FSH1 26641 64024	FSKRA 26032 62660	FSKR8 26022 62646
FSKRC 26012 62634	FSKRF 26000 62620	FSKRK 25999 62617
FSK 26033 62661	FSMNO 25987 62603	FSMN 25988 62604
FSM0 25985 62601	HE 25983 62577	IALT 25977 62571
IOEL 25976 62570	INOLAS 25965 62555	INDP 25955 62543
INOPS 25953 62541	INOSTP 25902 62456	INDTYP 25900 62454
IPRINT 23213 55255	JINPUT 25890 62442	KS 25888 62440
LP2 25886 62436	NCOUNT 23212 55254	NSR 25883 62433
NS 25884 62434	OGIVEK 25881 62431	PRALIN 25810 62322
PRAL 25870 62416	PRAT 25809 62321	PROS 25683 62130
PRP 25687 62127	PRSAVE 25686 62126	RH0CAL 25101 61015
PS1 25225 61211	PS 25685 62125	RN 25038 60716
RETHET 23219 55263	REX 23218 55262	RS 24987 60633
RH0E 25041 60721	RH0STG 25039 60717	SHANGL 24862 60436
RNS 25037 60715	RSC 24986 60632	STRLL 23207 55247
SCHLIN 24984 60630	SCL 24982 60626	TESTRA 24500 57664
SIGMAC 24861 60435	SIGMAU 24741 60245	TITLE2 24484 57644
STRUL 23206 55246	TAUM 24620 60054	TNNOP 24398 57516
THETAT 24499 57663	TIN 24497 57661	UE 24275 57323
TITLE3 24472 57630	T 24680 60150	UM 24272 57320
TNN0 24399 57517	U12 24336 57420	XL 23430 55606
UINF 24274 57322	UM1 24212 57224	XU12 23377 55521
U 24396 57514	WDOT 24032 56740	YTH 23256 55330
XL5 23429 55605	US 24092 57034	
Y12 23208 55250	XRN 23379 55523	
	Y 23376 55520	
	YTHC 23255 55327	

SUBROUTINE PRTERH (X,NSTART,NEND,K)

SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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```
100 X=X
    NSTART=NSTART
    VEND=VEND
    KS=KS
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7700 IF (NEND)-NSTART)800,750,800
7750 IF (INDSTR) 760,760,950
```

760 XRM=(X-DELXOD)/RNS(KS)
GO TO 909

SUBROUTINE PRTERH IX,NSTART,NEND,KS)

```

800 XRM=(X-DELTAX)/RNS(KS)
900 IF (INOPSIKS)-2) 910,920,930
910 PR=PS(1,KS)*(COSFI XRM)1#2
PRP=-PS(1,KS)/RNS(KS)*SINF(2.0*XRM)
PRSAVE=PR
GO TO 1000
920 PR=PS(2,KS)+PS(3,KS)*XRM+PS(4,KS)*XRM**2+PS(5,KS)*XRM**3+PS(6,KS)*
1XRM**4
PRP=RNS(KS)*(PS(3,KS)+2.0*PS(4,KS)*XRM+3.0*PS(5,KS)*XRM**2+4.0*PS(
16,KS)*XRM**3)
PRSAVE=PR
GO TO 1000
930 PR=PS(7,KS)/(PS(8,KS)+XRM)
PRP=-PS(7,KS)*RNS(KS)/(X+PS(8,KS)*RNS(KS))**2
PRSAVE=PR
GO TO 1000
950 PR=PRDS+X/DIST*IPRSAVE-PRDS)
PRP=(PRSAVE-PRDS)/DIST
1000 IF (NEND-NSTART) 1005,1090,1005
1005 NEND=NEND+1
DELT12=.5*DELTAP
SDEL12=SORTF(DELT12)
SDELT12=.58579*SORTF(DELTAP)
DELT12=.58579*DELTAP
AH12=12.0*FH(2)-FH(1)-FH(3))/SDELT12
BH12=(FH(3)+.414*FH(1)-1.414*FH(2))/DELT12
FH(NEND)=FH(1)+AH12*SDEL12+BH12*DELT12
FH12=FFH(NEND)
DHOP12=.5*AH12/SDEL12+BH12
AU12=(2.0*U(2)-U(3))/SDELT12
BU12=(U(3)-1.41421*U(2))/DELT12
U(NEND)=AU12*SDEL12+BU12*DELT12
U12=U(NEND)
GUDP12=.5*AU12/SDEL12+BU12
GO 1030 I=1,NS
AC12(1)=(2.0*C(2,1)-C(1,1)-C(3,1))/SDELT12
BC12(1)=(C(3,1)+.414*C(1,1)-1.414*C(2,1))/DELT12
IF (C(3,1)+C(2,1)) 1010,1015,1010
1010 IF (C(2,1)+C(1,1)) 1020,1015,1020
1015 C(NEND,1)=0
GO TO 1025
1020 C(NEND,1)=C(1,1)+AC12(1)*SDEL12+BC12(1)*DELT12
IF (C(NEND,1)) 1022,1025,1025
1022 C(NEND,1)=.5*(C(1,1)+C(2,1))
CDDP12(1)=(C(2,1)-C(1,1))/DELTAP
GO TO 1030
1025 GDDP12(1)=.5*AC12(1)/SDEL12+BC12(1)
1030 C12(1)=C(NEND,1)
1090 GO 1100 N=NSTART,NEND
1100 FSH(N)=FH(N)-.5*U(N)**2
IF (A2) 1150,1110,1115
1115 IF (A2-9.9) 1110,1110,1150
1150 PLUG=.43429448*LOGF(PR/2117.)
C8=230.6335/110.-PLUG)+.183042*(PLUG+3.)

```

C9=2.1965+.31961*(PLDG+4.1)**2
E4=(C9-C8)/(C8+C9-C9-79.4)

PAGE 3

SUBROUTINE PRIERH (X,NSTART,NEND,K5)

```

F2=79.4*(1.+E4)*(C8-79.4)
E1=(79.4-E2)*E4
E3=-E1+E4
C5=-2.1965+1.46434/(EXPF(-2.*PLOG)+1.)
C6=-.00065+.012096/(PLOG+.6)
C7=-94.2-1.6*PLOG*(1.-.5*PLOG)
C8=5224./(33.842-PLOG)-1.7609*(PLOG+.68.5)
C9=12.813+.46218*(PLOG+.1)**2
K4=(C9-C8)/(C8+CK8-CK9-79.4)
CK2=79.4*(1.+CK4)*(CK8-79.4)
CK1=(79.4-CK2)*CK4
CK3=-CK1*CK4
CK5=-1.83+1.098/(EXPF(-2.*(PLOG-.75))+1.)
CK6=.00038+.000953/(PLOG+.4.5)
CK7=-84.6-.8*PLOG*(1.-.5*PLOG)
IF(A2-9.8) 1155,1155,1110
1155 DO 1160 I=NSTART,NEND
      HBAR(I)=FSH(I)/25037.807
      D1=HBAR(I)/H465.
      D2=EXPF(HBAR(I)/1693.-10.)
      D3=HBAR(I)/33.86
      F1=F1+F2*D1+F3/(E4+D1)+C5*EXPF(-C6*(D3+C7)**2)+(5.4913-.56743*(PLOG+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(CK4+D1)+CK5*EXPF(-CK6*(D3+CK7)**2)+(9.2217-.276139*(PLOG+.3.5)**2)*D2
      T(I)=273.16+F1
      TM(I)=T(I)
1160 RH0(I)=PR*1.1799716F-6/F2
      GO TO 1200
1110 DO 1120 N=NSTART,NFND
      TNUM(N)=FSH(N)-1726.0F-18*(.5*C(N,2)*D02/FSM0+.5*C(N,4)*DN2/FSMN+C(N,5)*DN2D02/FSMN0+C(N,6)*(F1N0-DN2D02)/FSMN0P)
1120 T(N)=TNUM(N)/CP
1200 DO 1250 N=NSTART,NEND
      FL02(N)=TV02/T(N)/(EXPF(TV02/T(N))-1.0)
      FLN2(N)=TVN2/T(N)/(EXPF(TVN2/T(N))-1.0)
      FLN0(N)=TVN0/T(N)/(EXPF(TVN0/T(N))-1.0)
      FLN0P(N)=TVN0P/T(N)/(EXPF(TVN0P/T(N))-1.0)
      IF(A2) 1500,1300,1300
1300 DO 1350 N=NSTART,NFND
      TM(N)=TNUM(N)/(R*(C(N,1)/FM(1)*(FL02(N)+3.5)+C(N,3)/FM(3)*(FLN2(N)+3.5)+C(N,5)/FM(5)*(FLN0(N)+3.5)+C(N,6)/FM(6)*(FLN0P(N)+3.5)+2.5*(2C(N,2)/FM(2)+C(N,4)/FM(4)+C(N,7)/FM(7)))
1400 DO 1450 N=NSTART,NFND
      IF(ABS(F(TM(N)-T(N))/TM(N))-EPS1T)1450,1450,1470
1450 CONTINUE
      GO TO 1500
1470 DO 1480 N=NSTART,NEND
1480 T(N)=TM(N)
      GO TO 1200
1500 DO 1520 N=NSTART,NEND
      SUMCM=0.0
      T(N)=TM(N)
      DO 1510 I=1,NS

```

1510 SUMCM=SUMCM+C(N,1)/FM(1)
RTM=RTM(N)

PAGE 4

SUBROUTINE PRTRH (X,NSTART,NEND,KS)

```

1517 IF(A2) 1519,1517,1517
1519 RHO(N)=PR/(RTM*SUNCM)
      FSH1(N,1)=RTM*(3.5+FL02(N))/FM(1)
      FSH1(N,2)=RTM*2.5/FM(2)+DN2*.5/FM(2)
      FSH1(N,3)=RTM*(3.5+FLN2(N))/FM(3)
      FSH1(N,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(N,5)=(RTM*(3.5+FLN0(N))+DN2002)/FM(5)
      FSH1(N,6)=(RTM*(3.5+FLNOP(N))+F1N0+DN2002)/FM(6)
1520 FSH1(N,7)=RTM*2.5/FM(7)
      FSH12=FSH(NEND)
      RHO12=RHO(NEND)
      T12=T(NEND)
      FMUL2=3.04566E-8*TM(NEND)**1.5/(110.333+TM(NEND))
      DO 1600 1=1,NS
1600 FSH112(1)=FSH1(NEND,1)
      NEND=NEND-1
      IF(A2-9.9) 2000,2000,1700
1700 HBAR(1)=FSH(1)/25037.807
      D1=HBAR(1)/8465.
      D2=EXPF(HBAR(1))/1693.-10.)
      D3=HBAR(1)/33.86
      F1=E1+E2*D1+F3/(F4+D1)+C5*EXPF(-C6*(D3+C7)**2)+(5.4913-.56743*(PL0
18+1.75)**2)*D2
      F2=CK1+CK2*D1+CK3/(C*4+D1)+CK5*EXPF(-CK6*(D3+CK7)**2)+(9.2217-.276
139*(PL0G+3.5)**2)*D2
      T(1)=273.16#F1
      TM(1)=T(1)
      RHO(1)=PR*1.1799714E-6/F2
      FL02(1)=TV02/T(1)/EXPF(TV02/T(1))-1.0)
      FLN2(1)=TVN2/T(1)/EXPF(TVN2/T(1))-1.0)
      FLN0(1)=TVN0/T(1)/EXPF(TVN0/T(1))-1.0)
      FLNOP(1)=TVNOP/T(1)/(EXPF(TVNOP/T(1))-1.0)
      RTM=R*TM(1)
      FSH1(1,1)=RTM*(3.5+FL02(1))/FM(1)
      FSH1(1,2)=RTM*2.5/FM(2)+DN2*.5/FM(2)
      FSH1(1,3)=RTM*(3.5+FLN2(1))/FM(3)
      FSH1(1,4)=RTM*2.5/FM(4)+DN2*.5/FM(4)
      FSH1(1,5)=(RTM*(3.5+FLN0(1))+DN2002)/FM(5)
      FSH1(1,6)=(RTM*(3.5+FLNOP(1))+F1N0+DN2002)/FM(6)
      FSH1(1,7)=RTM*2.5/FM(7)
2000 RETURN
END(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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DEC OCT
1463 02667

DEC OCT
23207 55247

STORAGE NOT USED BY PROGRAM

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

AIL 32561 77461
A4L 32556 77454
A4T 32551 77447
A8T 32546 77442
AUI2 32523 77413
B5T 32282 77032
B8T 32100 76544
B8T 32095 76537
C12 31413 75265
C42 30133 72665
C 32013 76425
DPL 28910 70356
DHOPI2 28905 70351
DN2 27703 66067
EDENS 27697 66051
FPSIU 27633 65761
FFDA 27628 65754
FHE 27504 65560
FINO 27323 65273
FLEWL 27258 65172
FL272 26958 64516
FMUTLP 26827 64313
FNJREF 23216 55260
FSHP 26034 62662
FSKRQ 26002 62622
FSMF 25989 62605
GAMM 25984 62600
INDCJO 25975 62567
INDR 25903 62457
JBYCTR 23211 55253
NCOUNT 23212 55254
OGIVFK 25981 62431
PRAT 25909 62321
PRSAVE 25686 62126
PS 25685 62125
RDX 23218 55262
RHDSIG 25039 60717
RSM 24985 60631
SCI 24922 60532
STADIS 24681 60151
THFIAT 24499 57653
TITLE3 24472 57630
TVNO 24399 57517
UINF 24274 57322
U 24396 57514

A1T 32560 77460
A4T 32555 77453
A8T 32550 77446
AC12 32545 77441
B1T 32522 77412
B6T 32222 76736
B8T 32099 76543
BH12 32085 76525
CCALC 31353 75171
CM 30743 74027
CSR 28930 70402
DELTA 28909 70355
DIST 28904 70350
DNO 27701 66065
EPSIC 27636 65764
FTA 27632 65760
FEDB 27627 65753
FHM2 27443 65463
FKPSI 27321 65271
FLEWT 27198 65076
FL 27161 65175
FMUTLP 26767 64217
FSH12 23210 55252
FSH 26705 64121
FSKRE 26001 62621
FSMNOP 25986 62602
HF 25983 62577
INDLAS 25965 62555
INDSTP 25902 62456
JINPUT 25890 62442
NPSI 25885 62435
PE 25872 62420
PRDIRA 25748 62224
P 25880 62430
QW 25164 61114
RH012 25040 60720
RN 25038 60716
RS 24987 60633
SHANGL 24862 60436
T12 23209 55251
THPER 24498 57662
TM 24460 57614
TV02 24397 57515
ULOLIM 24273 57321
US 24092 57034

A2 32559 77457
A5L 32554 77452
A8T 32549 77445
AH12 32535 77427
B2T 32462 77316
B7T 32162 76642
B8T 32098 76542
BLOCK 32084 76524
CC 31403 75253
CONCAN 29533 71535
CS 29530 71532
DELTA 28908 70354
DKDL 28903 70347
D02 27700 66064
EPSIH 27635 65763
FA 27631 65757
FEDC 27626 65752
FHM 27503 65557
FK 27322 65272
FLN2 27138 65002
FM 26898 64422
FNDSH 26707 64123
FSHF 26645 64025
FSKPA 26032 62660
FSKRF 26000 62620
FSMNO 25987 62603
HH 25982 62576
INDPRI 25954 62542
INDSTR 25901 62455
JS 25889 62441
NSR 25883 62433
PRALIN 25810 62322
PRDS 25688 62130
PSCALC 25285 61305
RESTAP 25162 61112
RHOCAL 25101 61015
RNS 25037 60715
SCHLIN 24984 60630
SIGMAC 24861 60435
TAUM 24620 60054
TIN 24497 57661
T 24680 60150
U12 24336 57420
UM1 24212 57224
WDOT 24032 55740

A3L 32558 77456
A5T 32553 77451
A8T 32548 77444
ALPHA 32514 77426
B3T 32402 77222
B8T 32102 76546
B8T 32097 76541
BSR 32024 76430
CPF 29531 71533
CSUR 23214 55256
DELX00 28907 70353
DKOT 28303 67217
DSKRIIP 27699 66063
EPSI 27637 65765
FH 27630 65756
FH12 27565 65655
FH 27625 65751
FLELIN 27260 65174
FMUL12 26828 64314
FNDSL 26706 64122
FSH112 26044 62674
FSKRK 26022 62646
FSKRN 25988 62604
IALT 25977 62571
INDP 25955 62543
INDYIP 25900 62454
LP2 25886 62436
NS 25884 62434
PRAL 25870 62127
PRP 25687 62127
PSI 25225 61211
RETHET 23219 55263
RHOF 25041 60721
R 25163 61114
SCHTIN 24983 60627
SIGMAH 24801 60341
TAUP 24560 57760
TITLE1 24496 57660
TVN2 24400 57520
UCALC 24335 57417
UM2 24152 57130
XI 23431 55607

A3T 32557 77455
A8T 32552 77450
A8T 32547 77443
ASR 32533 77425
B4T 32342 77126
B3T 32101 76545
B3T 32096 76540
BU12 32014 76416
CM1 30143 72677
CP 29532 71534
OCOP12 28920 70370
DELXST 28906 70352
DN2902 27702 66066
DUP012 27698 66062
EPSIT 27634 65762
FC 27629 65755
FHCALC 27564 65654
FHS 27383 65367
FLFTIN 27259 65173
FLN 27078 64706
FMUL 26888 64410
FNURFW 23215 55257
FSHI 26644 64724
FSKRC 26012 62634
FSK 26033 62641
FSMN 25985 62601
IDEL 25976 62570
INDPS 25353 62541
IPPRINT 23213 55255
L 25887 62437
OGIVEH 25982 62432
PRATIN 25749 62225
PR 25871 62417
PSITCU 25165 61115
REW 23217 55261
RHQ 25161 61111
RSC 24986 60632
SCL 24982 60626
SIGMAU 24741 60245
TESTRA 24500 57664
TITLE2 24484 57664
TVNIP 24398 57516
UF 24275 57323
UM 24212 57320
XL 23430 55606

XLS 23429 55605
YCALC 23316 55424
Z1L 23243 55313
72 23231 55277

XRN 23379 55523
Y 23376 55520
Z1R 23242 55312
Z2S 23220 55264

XS 23378 55522
YTHC 23255 55327
Z1 23244 55314

XJ12 23377 55511
YTH 23256 55330
Z1S 23232 55300

Y12 23208 55250
YTHJ 23245 55315
Z2R 23230 55276

SUBROUTINE PRTERH (X,NSTART,NEND,KS)

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN DIMENSION AND EQUIVALENCE STATEMENTS

DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
HRAR	1462 02666	TNUM	1402 02572				

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

C5	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
CK1	1342	02476	C6	1341 02475	C1	1340 02474	C8	1339 02473
CK6	1337	02471	CK2	1336 02470	CK3	1335 02467	CK4	1334 02466
CK7	1332	02464	CK7	1331 02463	CK8	1330 02462	CK9	1329 02461
D2	1327	02457	D3	1326 02456	DFL112	1325 02455	OFLTP	1324 02454
E2	1322	02452	E3	1321 02451	E4	1320 02450	F1	1319 02447
N	1317	02445	PLOG	1316 02444	RTM	1315 02443	SDEL12	1314 02442
SUMCM	1312	02440	XRM	1311 02437			SOELTP	1313 02441

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

1)	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
CJG2	1293	02415	2)	1223 02307	3)	1230 02316	6)	1287 02407
CJ102	1304	02430	CJG2	1305 02431	CJG3	1306 02432	CJ100	1307 02433
E1F	1309	02435	CJ103	1310 02436	DJ408	321 00501	DJ508	320 00500
	365	00555	FJ1K	1005 01755				

LOCATIONS OF NAMES IN TRANSFER VECTOR

CJS	DEC	UCT	DEC	UCT	DEC	UCT	DEC	UCT
SOET	0	00000	EXP	4 00004	EXP(3	5 00005	LOG	3 00003
	2	00002					SIN	1 00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

CJS	EXP	EXP(3	LOG	SIN	SOET
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND ACTUAL LOCATIONS

FFN	IFN	LOC	FFN	IFN	LOC	FFN	IFN	LOC
100	11	00113	700	16	00136	750	17	00143
900	21	00157	910	22	00163	920	26	00212
1000	36	00346	1005	37	00351	1010	56	00524
1022	61	00560	1025	64	00573	1030	65	00600
1115	69	00627	1150	70	00634	1155	90	01122
1120	103	01337	1200	104	01345	1250	108	01414
1400	112	01522	1450	114	01541	1470	116	01544
1510	123	01575	1517	126	01616	1519	127	01624
1700	142	01756	2000	163	02272			

SUBROUTINE RADBDY

```

21=(X-XS)*COSF(CONEAN)+Z1S
GO TO 230
220 Z2=(X-XLS(KS-1))*SINF(CONEAN)+Z2S
Z1=(X-XLS(KS-1))*CCSF(CONEAN)+Z1S
230 RSM=Z2
GO TO 330
300 Z2=Z2S
RSM=Z2
IF(KS-2)310,320,320
310 Z1=Z1S*(X-XS)
GO TO 330
320 Z1=X-XLS(KS-1)+Z1S
330 IF(EPSI) 550,700,800
400 GO TO 100
500 GO TO 300
550 STOP 550
700 RSM=1.0
800 RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE RADBDY

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STORAGE NOT USED BY PROGRAM

 DEC OCT
 193 003C1

 DEC OCT
 23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

AIL 32561 77461	DEC OCT	AIL 32560 77460	DEC OCT	A3L 32558 77456	DEC OCT	A3T 32557 77455	DEC OCT
A4L 32556 77454		A4T 32555 77453		A5L 32554 77452		AB1T 32552 77450	
AB2T 32551 77447		AB3T 32550 77446		AB4T 32549 77445		AB6T 32547 77443	
AB7T 32546 77442		AC12 32545 77441		AM12 32543 77440		ASR 32533 77425	
AU12 32523 77413		B1T 32522 77412		B2T 32462 77316		84T 32342 77126	
AS1 32282 77032		B6T 32222 76736		B7T 32162 76642		882T 32101 76545	
AB3T 32100 76544		BB4T 32099 76543		885T 32098 76542		887T 32096 76540	
HC12 32095 76537		BH12 32085 76525		BLOCK 32084 76524		BUI2 32014 76416	
C12 31413 75265		CCALC 31353 75171		CC 31403 75253		CM1 30143 72677	
CM2 30133 72665		CM 30743 74027		COMEAN 29533 71535		CP 29532 71534	
C 32013 76415		CSP 28930 70402		CS 29530 71532		DCDP12 28920 70370	
DEL 28910 70356		DELIAP 28909 70355		DELTAX 28908 70354		DELXST 28906 70352	
DHDP12 28905 70351		DIST 28904 70350		DKDL 28903 70347		DN2002 27702 66066	
DN2 27703 66067		DMQ 27701 66065		DU2 27700 66064		DUDP12 27698 66062	
EDENS 27697 66061		EPSIC 27636 65764		EPSIM 27635 65763		EPSIT 27634 65762	
FPSIU 27633 65761		ETA 27632 65760		FA 27631 65757		FC 27629 65755	
FEDA 27628 65754		FEDR 27627 65753		FEDC 27626 65752		FHCALC 27564 65654	
FHE 27504 65560		FHM2 27443 65463		FHM 27503 65557		FHS 27383 65367	
FIND 27323 65273		FKPSI 27321 65271		FK 27322 65272		FLETIN 27259 65173	
FLEWL 27258 65172		FLEWT 27198 65076		FLN2 27138 65002		FLMO 27078 64706	
FLO2 26958 64516		FL 27261 65175		FM 26898 64422		FMUL 26868 64410	
FMUTIM 26827 64313		FMUTIP 26767 64217		FNDSSH 26707 64123		FNUREW 23215 55257	
FNUREX 23216 55260		FSHE 26645 64025		FSH12 26044 62674		F5HP 26034 62662	
FSH 26705 64121		FSKRA 26032 62660		FSKRB 26022 62646		FSKRD 26002 62622	
FSKRI 26001 62621		FSKRF 26000 62620		FSKRC 26012 62634		FSME 25989 62605	
FSMNOP 25986 62602		FSMNO 25987 62603		FSMN 25988 62604		GAMM 25984 62600	
HE 25983 62577		HH 25982 62576		IALT 25977 62571		INDC00 25975 62567	
INDLAS 25965 62555		INDPRI 25954 62542		INDP 25955 62543		INDR 25903 62457	
INDSTP 25902 62456		INDSTR 25901 62455		INDTYP 25900 62454		JBYCTR 23211 55253	
JINPUT 25890 62442		JS 25889 62441		KS 25888 62440		L 25887 62437	
OGIVEK 25881 62431		NPSI 25885 62435		NSR 25883 62433		OGIVEM 25882 62432	
PRAT 25809 62321		PE 25872 62420		PRALIN 25870 62416		PRATIN 25749 62225	
PRSAVE 25686 62126		PROIRA 25748 62224		PRDS 25688 62130		PR 25871 62417	
P 25880 62430		P 25880 62430		PSCALC 25285 61305		PSITCU 25165 61115	
QW 25164 61114		QW 25164 61114		RESTAR 25162 61112		REW 23217 55261	
RHO12 25040 60720		RH 25038 60716		RHOAL 25101 61015		RHO 25161 61111	
RHO2 25039 60717		RS 24987 60633		RNS 25037 60715		RSC 24986 60632	
RSM 24985 60631		SHANGL 24862 60436		SCMLIN 24984 60630		SCL 24982 60626	
SCT 24922 60532		TAUM 24620 60054		SHANGL 24862 60436		SIGMAU 24741 60245	
STADIS 24681 60151		TIN 24497 57661		TAUP 24560 57760		THETAT 24499 57663	
THPR 24498 57662		T 24680 60150		TIN 24497 57660		TITLE3 24472 57630	
TM 24460 57614		U12 24336 57420		TVN2 24400 57520		TVNO 24399 57517	
TV02 24397 57515		U01 24212 57224		UCALC 24335 57417		UINF 24274 57322	
ULOLIM 24273 57321		W00T 24032 56740		UM2 24152 57130		U 24396 57514	
US 24092 57034		X 23432 56610		XI 23431 55607		XLS 23429 55605	
XRN 23379 55523		YTHC 23255 55327		YTH 23256 55330		YCALC 23316 55424	
Y 23376 55520		Z1 23244 55314		Z1S 23232 55300		Z1L 23243 55313	
Z1R 23242 55312						Z2 23231 55277	
Z2S 23220 55264							

SUBROUTINE RA080Y

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LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1) 188 00274	2) 180 00264	3) 181 00265	6) 182 00266	C1G0 191 00277	OEC OCT		
C1G1 192 00300	E11 18 00022	E12 24 00030	E15 88 00130	E1E 166 00246			
E1H 174 00256	E1109 142 00216						

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT
COS 1 00001	SIN 0 00000				

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

COS SIN

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
100 11 00024	120 12 00032	130 15 00070	190 17 00125	200 19 00132				
210 20 00136	220 23 00145	230 25 00213	270 27 00220	300 30 00230				
320 32 00235	330 33 00241	340 34 00245	350 35 00250	360 36 00251				
700 37 00253	800 38 00260							

PAGE 1

SUBROUTINE STAOUT(KK)

SUBROUTINE STAOUT(KK)

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COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
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2105T,2106T,2107T,2108T,2109T,2110T,2111T,2112T,2113T,21
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SUBROUTINE STAOUT(KK)

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5020 FORMAT(15H STAG DENSITY 6X3HNSR/14H (SLUGS/CU FT)/1PE13.5,110)
5025 FORMAT(/18H SHOCK REGION NO 12/6X4HTYPE10X6HSHANGLSX13HSTANDOFF
1 DIST19X9HGEOM COEF30X6HLIMITS/20X5H(RAD)10X4H(FT)12X3HASR12X3HBSR
212X3HCSR9X8HZ1R (FT)7X8HZ2R (FT))
5030 FORMAT(4X8HSTRAIGHT3X1PE13.5,1P6E15.5)
5035 FORMAT(4X7HCONICAL4X1PE13.5,1P6E15.5)
5038 FORMAT(5X6HNORMAL4X1PE13.5,1P6E15.5)
5040 FORMAT(3X12HPARABOLIC 1PE13.5,1P6E15.5)
5045 FORMAT(/34H PROBLEM PARAMETERS AND INDICATORS//13H PROBLEM TYPE/
1)
5050 FORMAT(5X15HINITIAL PROFILE15X24HCONSTANT EDGE CONDITIONS15X22HINI
TIAL PROFILES INPUT)
5055 FORMAT(5X15HINITIAL PROFILE15X15HSTREAMLINE CALC15X22HINITIAL PROF
ILES INPUT)
5060 FORMAT(5X14HSHOCK CROSSING16X15HSTREAMLINE CALC15X22HINITIAL PROFI
LES INPUT)
5065 FORMAT(/15H NO GRID PTS 15H NO SPECIES 15H NOSE RADIUS 15H
1 OVERALL ZETA 6X4HNPS110X6HJINPUT9X6HRESTAR/35X4H(FT)12X4H(FT)/1A,
2116,1P115.5,1PE15.5,111,114,1PE20.5)
5070 FORMAT(/6X2HXSI3X3HZISI2X3HZ2SI11X6HDELTAX/5X4H(FT)12X4H(FT)11X4H(F
IT)11X4H(FT)/1PE13.5,1P3E15.5)
5075 FORMAT(/6X3HAIL12X3HAIL12X2HA213X3HA3L12X3HA3T12X3HA4L12X3HA4T/1PE
113.5,1P6E15.5//6X3HA5L12X3HA5T11X20HSTEP SIZE TOLERANCEF57X12HSTAB.
2 FACTOR/1PE13.5,1P4E15.5)
5080 FORMAT(/4X7HU LOLIM4X418HTHICKNESS CRITERIA/4X8H(FT/SEC)10X1HU12X5
1HC(02)11X4HC(0)10X5HC(N2)11X4HC(N)10X5HC(N0)12X1HH/1PE13.5,1P7E15.
25)
5085 FORMAT(/4X4HEPSI5X6HEPSI U6X10HEPSI C(02)2X9HEPSI C(0)3X10HEPSI C(
IN2)2X9HEPSI C(N)3X10HEPSI C(N0)4X6HEPSI H7X6HEPSI T/1P8E12.5,1PE13
2.5)
5090 FORMAT(/11X8HLEWIS NO21X10HPRANDTL NO20X10HSCMIDT NO/4X,7HLAMINAR
17X9HTURBULENT7X7HLAMINAR7X9HTURBULENT7X7HLAMINAR7X9HTURBULENT/1PE1
23.5,1P5E15.5)
5095 FORMAT(/30H DIFFUSION COEF RATIOS LAMINAR/)
5100 FORMAT(6X2H0214X1H013X2HN214X1HN13X2HN013X3HNO+12X2HE-/1PE13.5,1P6
1E15.5)
5105 FORMAT(/32H DIFFUSION COEF RATIOS TURBULENT/)
5110 FORMAT(/4X6HTESTRA10X4HAB111X4HAB2T11X4HAB3T11X4HAB4T11X4HAB5T11X
14HAB6T11X4HAB7T/1PE13.5,1P7E15.5//20X4HBB1T11X4HBB2T11X4HBB3T11X4H
26B4T11X4HBB5T11X4HBB6T11X4HBB7T/1PE28.5,1P6E15.5//6X2HFK13X2HFA13X
32HFB13X2HFC13X4HFCDA11X4HFCDB11X4HFCDC/1PE13.5,1P6E15.5)
5115 FORMAT(/37H SUBREGION VALUES AND WALL PARAMETERS)
5120 FORMAT(/11H PRES TYPE37X9HPRES COEF/18,1PE17.5,1P7E13.5//3X9HGE0
1M SUBR6X6HOGIVEH9X6HOGIVEK10X2HRN13X2HXL11X6HCONEAN6X12HPRINTOUT I
2NT/21X4H(FT)11X4H(FT)10X4H(FT)11X4H(FT)10X5H(RAD)/19,1PE19.5,1P4E1
35.5,111)
5125 FORMAT(/11H WALL COEF//6X2H0214X1H013X2HN214X1HN13X2HN013X3HNO+1
12X2HE-9X11HH WALL COEF/(1PE13.5,1P7E15.5))
5130 FORMAT(18H1 INITIAL PROFILES//6X14Y10X5HC(02)8X4HC(0)9X5HC(N2)8X4H
1C(N)9X5HC(N0)8X6HC(N0+)7X5HC(E-)10X1HH12X1HU/4X4H(FT)97X10H(FT/SEC
2)5Q4X8H(FT/SEC))
5135 FORMAT(1P10E13.5)
5140 FORMAT(15H1STATION VALUES3X15,4I10//)
5145 FORMAT(7X1HX11X7HDELTA XB6HZETA 19X8HRAID BODY4X12HRL MASS FLOW3X1
14HSTREAMTUBE RAD3X9H WALL PRES7X7HRETHETA/5X4H(FT)11X4H(FT)11X4H(FT
2)12X4H(FT)7X11H(LB SEC/FT)7X4H(FT)18X10H(LB/SQ FT)/1P4E15.7,1PE13.5

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SUBROUTINE STAOUT(KK)

[illegible]

SUBROUTINE STAOUT(KK)

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6020 CONTINUE
      WRITE OUTPUT TAPE 6,5045
      IF (INDSTR) 6025,6030,6035
6025 WRITE OUTPUT TAPE 6,5050
      GO TO 6040
6030 WRITE OUTPUT TAPE 6,5055
      GO TO 6040
6035 WRITE OUTPUT TAPE 6,5060
6040 WRITE OUTPUT TAPE 6,5065,L,NS,RN,Z1L,NPSI,JINPUT,RESTAR
      WRITE OUTPUT TAPE 6,5070,XS,Z1S,Z2S,DELTA
      WRITE OUTPUT TAPE 6,5075,A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,FNDSSL
1,FNDSSH,TIN
      WRITE OUTPUT TAPE 6,5080,ULOLIM,THPER,THPER,THPER,THPER,THPER,THPE
IR,THPER
      WRITE OUTPUT TAPE 6,5085,EPSI,EPSIU,EPSIC,EPSIC,EPSIC,EPSIC,EPSIC,
1EPSIH,EPSIT
      WRITE OUTPUT TAPE 6,5090,FLELIN,FLELIN,FLELIN,PRALIN,PRALIN,SCHLIN,SCHTIN
      WRITE OUTPUT TAPE 6,5095
      WRITE OUTPUT TAPE 6,5100,DKDL(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5105
      WRITE OUTPUT TAPE 6,5110,DKDT(1,I),I=1,NS)
      WRITE OUTPUT TAPE 6,5110,TESTRA,AB1T,AB2T,AB3T,AB4T,AB5T,AB6T,AB7T
1,BB1T,BB2T,BB3T,BB4T,BB5T,BB6T,BB7T,FK,FA,FB,FC,FEDA,FEDR,FEDC
      RETURN
C SUBREGION VALUES
6041 WRITE OUTPUT TAPE 6,5115
      WRITE OUTPUT TAPE 6,5120,INDP,(P(I),I=1,8),INDR,OGIVEH,OGIVEK,RN,X
1L,CONEAN,INDPRI
      WRITE OUTPUT TAPE 6,5125,((CC(J,I),I=1,NS),HH(J),J=1,5)
      WRITE OUTPUT TAPE 6,5130
      DO 6045 N=1,LP2
6045 WRITE OUTPUT TAPE 6,5135,Y(N),(C(N,I),I=1,NS),FH(N),U(N)
      RETURN
C STATION VALUES
C
6046 IF (KK-9) 60465,6048,6048
60465 IPRINT=IPRINT+1
6047 IF (IPRINT-INDPRI) 6170,6048,6048
6048 WRITE OUTPUT TAPE 6,5140,JS,IDEL,KK,IPRINT,INDPRI
      IF (EPSI) 6055,6050,6055
6050 FMBL=PSI(L)
      DIN2=PSI(L)/(RHOE*UINF)
      GO TO 6080
6055 AREA=0.0
      DO 6075 I=1,L
      IF (I-1) 6060,6065,6060
6060 IF (I-L) 6070,6065,6070
6065 AREA=AREA+(RS+Y(I)*COSF(THETAT))*0.5
      GO TO 6075
6070 AREA=AREA+(RS+Y(I)*COSF(THETAT))
6075 CONTINUE
      CONSTA=6.2831852/RS
      FMBL=AREA*CONSTA*DELTAP
      UIN2=50RTF(FMBL/(3.1415926*RHOE*UINF))
6080 AREA1=0.0

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SUBROUTINE STAOUT(KK)
  DO 6100 I=2,L
    IF(I-2) 6085,6090,6085
    6085 IF(I-L) 6095,6090,6095
    6090 AREA1=AREA1+(U(L)-U(I))*5
    GO TO 6100
    6095 AREA1=AREA1+(U(L)-U(I))
    6100 CONTINUE
    DO 303 N=1,LP2
      BLOCK(N)=U(N)
    303 CALL CONPRG(9)
      YTHU=YTH
    DO 313 N=1,LP2
      BLOCK(N)=FH(N)
    313 CALL CONPRG(9)
      YTHH=YTH
    DO 323 I=1,NS
      DO 323 N=1,LP2
        BLOCK(N)=C(N,I)
      CALL CONPRG(9)
    323 YTHC(I)=YTH
      THETA=AREA1/RS*DELTAP/(RHO(L)*U(L)**2)
      RETHET=(RHO(L)*U(L)*THETA)/FMUL(L)
      REX=(RHO(L)*U(L)*X)/FMUL(L)
      REW=(RHO(L)*U(L)*X)/FMUL(L)
      IF(FH(1)-FH(2)) 440,400,440
    400 DHDP12=0
    GO TO 440
    440 DO 540 I=1,NS
      IF(C(1,I)-C(2,I)) 540,500,540
    500 DCOPI2(I)=0
    GO TO 540
    540 CONTINUE
    GARB=0
    DO 560 I=1,NS
      GARB=GARB+FSH(1,I)*DKDL(1,I)*5* AAU*AC12(I)
      FNUREW=X*RS/SQRTF(REW)*(.5*AAU*AH12+FLEWL(1)*GARB)/(FH
1(L)-FH(1))
      FNUREX=FNUREW*SQRTF(REW/REX)
      DESTAR=Y(L)-(PSI(L)/RHO(L)/U(L)/RS)
      CSUB=TAUM(1)/(.5*RHO(L)*U(L)**2)
      WRITE OUTPUT TAPE 6,5145,X,DELTAX,Z1,RSM,FMBL,DIN2,PRSAVE,RETHET
      WRITE OUTPUT TAPE 6,5150,YTHU,YTHH,(YTHC(1),I=1,NS)
      WRITE OUTPUT TAPE 6,5155,REX,REW,DESTAR,THETA,FNUREX,FNUREW,CSUB
      WRITE OUTPUT TAPE 6,5160
    DO 6108 N=1,LP2
      CSUM=0.0
    DO 6106 I=1,NS
      CSUM=CSUM+C(N,I)
    6106 WRITE OUTPUT TAPE 6,5161,N,(C(N,I),I=1,NS),CSUM
    6108 IF(EPSI) 6120,6110,6120
    6110 WRITE OUTPUT TAPE 6,5165
    DO 6115 N=1,LP2
      WRITE OUTPUT TAPE 6,5166,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
1N)
    GO TO 6130

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SUBROUTINE STAOUT(KK)
6120 WRITE OUTPUT TAPE 6,5170
DO 6125 N=1,LP2
6125 WRITE OUTPUT TAPE 6,5171,N,PSI(N),Y(N),U(N),T(N),FSH(N),FH(N),RHO(
IN)
6130 WRITE OUTPUT TAPE 6,5175
DO 6135 N=1,LP2
EDENS(N)=5.664696E26*(N.7)*RH0(N)
6135 WRITE OUTPUT TAPE 6,5176,N,EDENS(N),FMUL(N),FMUT1P(N),TAUM(N)
EDEN12=5.664696E26*C12(7)*RH012
WRITE OUTPUT TAPE 6,6136,U12,FH12,RH012,T12,Y12,FSH12,TAUM(2),EDEN
12,(C12(1),I=1,NS)
6136 FORMAT(1H03X5HU 1/210X6HFH 1/29X7HRHO 1/28X5HT 1/210X5HY 1/210X8HS
IM H 1/26X8HTAUM 1/27X8HEDEN 1/2/1H 1P8E15.5/9H0C(I) 1/2/1H 1P7E15.
25)
IF (KK-9) 6138,6139,6139
6138 IPRINT=0
6139 IF (SENSE SWITCH 3) 6140,6150
6140 WRITE OUTPUT TAPE 6,5180
DO 6145 N=1,LP2
6145 WRITE OUTPUT TAPE 6,5185,N,(WDOI(N,I),I=1,NS)
6150 IF (SENSE SWITCH 5) 6155,6170
6155 WRITE OUTPUT TAPE 6,5190
WRITE OUTPUT TAPE 6,5195
DO 6165 N=1,LP2
DO 6160 I=1,NS
C MODIFY DSCRIP FOR SUBSCRIPT VARIABLE WHEN CHANGED IN MP
6160 PRDIRA(I)=WDOI(N,I)*DELTAP/RHO(N)/U(N)/RS/DSCRIP
6165 WRITE OUTPUT TAPE 6,5200,N,(PRDIRA(I),I=1,NS)
6170 RETURN
END(1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0)

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SUBROUTINE STAOUT(KK)

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STORAGE NOT USED BY PROGRAM

DEC OCT
2087 04047

DEC OCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455	
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	AST 32553 77451	CAU 32504 55244	
AB1T 32552 77450	AB2T 32551 77447	AB3T 32550 77446	AB4T 32549 77445	ARST 32548 77444	
AB6T 32547 77443	AB7T 32546 77442	AC12 32545 77441	AH12 32535 77427	ALPHA 32534 77426	
ASK 32533 77425	AU12 32523 77413	B1T 32522 77412	B2T 32462 77316	R3T 32402 77222	
R4T 32342 77120	B5T 32282 77032	B6T 32222 76736	B7T 32162 76642	B81T 32102 76546	
BB2T 32101 76545	BB3T 32100 76544	BB4T 32099 76543	BB5T 32098 76542	BB6T 32097 76541	
BB7T 32096 76540	BC12 32095 76537	BH12 32085 76525	RLOCK 32084 76524	BSR 32024 76430	
BUI2 32014 76410	C12 31413 75265	CCALC 31353 75171	CC 31403 75253	CE 30753 74041	
CM1 30143 72677	CM2 30133 72665	CM 30743 74027	CONJAN 29533 71535	CPE 29531 71533	
CP 29532 71534	C 32013 76415	CSR 28930 70402	CS 29530 71532	CSUP 23214 55256	
DCUP12 28920 70370	DEL 28910 70356	DELTAP 28909 70355	DELTA 28908 70354	DELXOD 28907 70353	
DELXST 28906 70352	DHDP12 28905 70351	DIST 28904 70350	DKOL 28903 70347	DKOT 28303 67217	
DN2002 27702 66066	DN2 27703 66067	DNO 27701 66065	D02 27700 66064	DSCRIP 27349 66063	
DUOP12 27698 66062	EDENS 27697 66061	EPSC 27636 65764	EPSIH 27635 65763	EPSI 27637 65765	
EPSIT 27634 65762	EPSIU 27633 65761	ETA 27632 65760	FA 27631 65757	FB 27630 65756	
FC 27629 65755	FEDA 27628 65754	FEDR 27627 65753	FEDC 27626 65752	FH12 27565 65655	
FHCALC 27564 65654	FHE 27504 65560	FHM2 27443 65463	FHM 27503 65557	FH 27625 65751	
FHS 27383 65367	FINO 27323 65273	FKPS1 27321 65271	FK 27322 65272	FLELIN 27260 65174	
FLETIN 27259 65173	FLEWL 27258 65172	FLEWT 27198 65076	FLN2 27138 65002	FLNOP 27018 64612	
FLNO 27078 64706	FLO2 26958 64516	FL 27261 65175	FM 26898 64422	FLNOL 26328 64314	
FMUL 26888 64410	FMUT1M 26827 64313	FMUT1P 26767 64217	FNDSSH 26707 64123	FMUL12 26328 64314	
FMUREX 23215 55257	FJUREX 23216 55260	FSH12 23210 55252	FSHE 26645 64025	FNDSSL 26706 64122	
FSHREW 23215 55257	FSHP 26034 62662	FSH 26705 64121	FSKRA 26032 62660	FSH112 26044 62574	
FSKRC 26012 62634	FSKRD 26002 62622	FSKRE 26001 62621	FSKRF 26000 62620	FSKRR 26022 62646	
FSK 26033 62601	FSME 25989 62605	FSMNOP 25986 62602	FSMNO 25987 62603	FSKRR 25999 62617	
FSMO 25985 62601	GAMA 25984 62600	HE 25983 62577	HH 25982 62576	FSMN 25988 62604	
IDEL 25976 62570	INDCOC 25975 62567	INDLAS 25965 62555	INDPRI 25954 62542	IALT 25977 62571	
INDPS 25953 62541	INDR 25903 62457	INDSTP 25902 62456	INDSTR 25901 62455	INDP 25955 62543	
IPRINT 23213 55255	JBYCTR 23211 55253	JINPUT 25890 62442	JUS 25889 62441	INDTYP 25900 62454	
LP2 25886 62436	L 25887 62437	NCOUNT 23212 55254	NPSI 25885 62435	KS 25888 62440	
NS 25884 62434	OGIVEL 25882 62432	OGIVEK 25881 62431	PE 25872 62420	NSR 25883 62433	
PRAL 25870 62416	PRATIN 25749 62225	PRAT 25809 62321	PRDIRA 25748 62224	PRALIN 25810 62322	
PRP 25687 62127	PR 25871 62417	PRSAVE 25686 62126	P 25880 62430	PRDS 25688 62130	
PSI 25225 61211	PSITCU 25165 61115	PS 25685 62125	OW 25164 61114	PSCALC 25285 61305	
RETHET 23219 55263	REK 23217 55261	REX 23218 55262	RH012 25047 60720	RESTAR 25162 61112	
RHOL 25041 60721	RHO 25161 61111	RSC 24943 60632	RH012 25047 60720	RHOCAL 25101 61015	
RNS 25037 60715	R 25163 61113	SCHLIN 24983 60627	RSM 24985 60631	RN 25038 60716	
SCHLIN 24984 60630	SIGMAH 24801 60341	SIGMAU 24741 60245	STADIS 24681 60151	SHANGL 24862 60436	
SIGMAC 24661 60435	T12 23209 55251	TAUM 24620 60054	TAUP 24560 57760	STRL 23207 55247	
STRUL 23206 55246	THPER 24498 57662	TIN 24497 57661	TITLE1 24496 57660	TESTRA 24500 57664	
THETAT 24499 57663	TN 24460 57614	T 24680 60150	TVN2 24400 57520	TITLE2 24484 57644	
TITLE3 24472 57630	TV02 24397 57515	U12 24336 57420	UCALC 24335 57417	TVNOP 24398 57516	
TVNO 24399 57517	ULOLIM 24273 57321	UM1 24212 57224	UM2 24152 57130	UC 24275 57323	
UIHF 24274 57324	US 24092 57034	WDOT 24032 56740	XI 23431 55607	UM 24272 57320	
U 24396 57514	XLS 23429 55605	Y12 23208 55250	YTHC 23255 55327	XL 23430 55606	
	Y12 23208 55250			XU12 23377 55521	
				YTH 23256 55330	

SUBROUTINE STAOUT(KK)

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YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
AREA1	2086 04046	AREA	2085 04045	CONSTA	2084 04044	CSUM	2083 04043
DIN2	2081 04041	EDEN12	2080 04040	FMBL	2079 04037	GARB	2078 04036
N	2076 04034	THETA	2075 04033	TINF	2074 04032	YTHH	2073 04031

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
8)458	5000 04015	8)45D	5005 04003	8)45I	5010 03742	8)45N	5015 03723
8)4T1	5025 03704	8)4T6	5030 03651	8)4TB	5035 03643	8)4TE	5038 03635
8)4TL	5045 03622	8)4TQ	5050 03607	8)4TV	5055 03571	8)4U4	5060 03555
8)4UE	5070 03506	8)4UJ	5075 03467	8)4UO	5080 03435	8)4UT	5085 03407
8)4V7	5095 03331	8)4VC	5100 03322	8)4VH	5105 03307	8)4VM	5110 03300
8)500	5120 03216	8)505	5125 03154	8)50A	5130 03133	8)50F	5135 03103
8)50P	5145 03073	8)50U	5150 03031	8)513	5155 02764	8)518	5160 02734
8)51D	5165 02713	8)51E	5166 02657	8)51I	5170 02653	8)51J	5171 02620
8)51O	5176 02570	8)51S	5180 02564	8)521	5185 02510	8)526	5190 02504
8)526	5200 02463	8)5V0	6136 02457			8)528	5195 02475

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1)	2062 04016	2)	1287 02407	3)	1294 02416	6)	1300 02424
C)62	2068 04024	C)63	2069 04025	C)102	2070 04026	C)200	2071 04027
E)7	147 00223	E)D	235 00353	E)F	250 00372	E)10	606 01136

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
ATAN	2 00002	CONPRG	5 00005	COS	3 00003	SORT	4 00004
(5TH)	0 00000					(FIL)	1 00001

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN CONPRG COS SORT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
5800	59 00035	6000	75 00162	6001	77 00174	6003	80 00225
6010	84 00260	6015	87 00307	6020	90 00337	6025	93 00354
6035	97 00373	6040	98 00401	6041	126 00763	6045	143 01104
27697	152 01143	6047	153 01146	6048	154 01153	6050	157 01201
6060	163 01224	6065	164 01231	6070	166 01246	6075	167 01260
6085	174 01322	6090	175 01327	6095	177 01336	6100	178 01342
313	185 01407	323	192 01440	400	198 01515	440	200 01523
540	204 01542	560	207 01556	6106	226 02002	6108	227 02010
6115	236 02053	6120	239 02103	6125	241 02114	6130	243 02143
6138	256 02250	6139	257 02252	6140	258 02254	6145	260 02276
6155	267 02317	6160	271 02344	6165	272 02361	6170	278 02403

SUBROUTINE STEPSZ

SUBROUTINE STEPSZ

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CC=MCN AIL,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,ABIT,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B83T,B84T,B85T,B86T,B87T,B88T,B89T,B90T,
3BLDCK,BSR,BU12,C,C12,CC,CCALC,CE,CM,CM1,CM2,CDNEAN,CP,CPE,CS,
4CSR,DCDP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5DKCT,DN2,DN2D02,DN2D02,DN2D02,DN2D02,DN2D02,DN2D02,DN2D02,
6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
7FECC,FF,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMCN FIND,FK,FKPSI,FL,FLELIN,FLELIN,FLEWL,FLEWT,
1FLN2,FLND,FLNDP,FLC2,FM,FML,FML12,FMLTIP,FMLTIP,FNDSSH,
2FNCSSL,FSH,FSME,FSH1,FSH12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMH,FSMD,FSMND,FSMNC,FSMD,GAMM,HE,
4HH,IALT,IUEL,INDCCO,INDLAS,INDP,INDPRI,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,JINPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
COMMCN PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RHD,
1RHDCAL,RHDE,RHC12,RHDSGT,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCI,S+ANGL,SIGMAC,SIGMAH,SIGMAU,
3STAC(S,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVM2,
5TVNC,TVADP,TV02,U,U12,UCALC,UE,UINF,ULDLIM,UM,UM1,
6UM2,US,WDDT,X,X1,XL,XLS,XPM,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHL,Z1,ZIL,ZIR,ZIS,Z2,Z2R,Z2S
COMMCN RETHET,REX,REW,FNUREX,FNUREM,CSUB,I,PRINT,NCOUNT,JBYCTR

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DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
1B6T(60),B7T(60),B8T(60),B83T(60),B84T(60),B85T(60),B86T(60),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKDL(60,10),DKDT(60,10),
4FDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEWL(60),FLEWT(2),FLN2(60),FLND(60),
6FLNCP(60),FLD2(60),FM(10),FMUL(60),FMUTIM(60),
DIMENSION FMUTIP(60),FSH(60),FSH1(60),FSH12(10),FSKRA(10),
1FSKR(10),FSKRC(10),FSKRK(10),HH(5),INDCDO(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(B),PRDIRA(60),
3PRAI(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHO(60),
4RHDCAL(60),RNS(50),SCL(60),SCI(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60),
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1WDDT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
2Z2R(10)

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50 IF((DEL-2) 100,200,300
100 DO 105 N=1,LP2

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US(N)=U(N)
U(N)=U(N)
U(N)=U(N)
F-S(N)=FH(N)
F(N)=FH(N)
DO 105 I=1,NS
CS(N,I)=C(N,I)
105 C(N,I)=C(N,I)
RSS=RS

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PAGE 2

SUBROUTINE STEPSZ

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IF(SENSE SWITCH 2)106.108
106 CALL STACUT(3)
108 CC 114 N=1.0LP2
    IF(UM(N)) 116.111.111
111 CC 112 I=1.0NS
    IF(CM(N,I)) 118.112.112
112 CC CONTINUE
    IF(FPM(N)) 118.113.113
113 IF(T(N))118.114.114
114 CC CONTINUE
    IF(SENSE SWITCH 5) 1142.1162
1142 CC 116 N=1.0L
    IF((UM(N+1)-UM(N))/UM(N+1)+.05) 118.116.116
116 CC CONTINUE
1162 IF(X+3.1*DELTAX-XL) 120.130.130
118 PRINT 119.N.X.DELTAX
119 FORMAT(3X23+STEP SIZE CRITERIA N=13.5H X=1PE13.5.10H DELTAX=
11PE13.5)
    ACCUN7=ACCUN7+1
    IF(NCCUN7-7) 515.600.600
120 RS=RSM
125 IDEI=IDEL+1
    X=X+DELTAX
    INCSTP=2
    RETURN
130 X=X+DELTAX
    RS=RSM
    INCSTP=3
    RETURN
200 IF (SENSE SWITCH 2) 202.206
202 CC 205 N=1.0LP2
    L(N)=UM(N)
    FH(N)=FPM(N)
    CC 205 I=1.0NS
    C(N,I)=CM(N,I)
205 CALL STACUT(3)
206 CC 210 N=1.0LP2
    U(N)=LS(N)
    UM2(N)=UM(N)
    FH(N)=FPM(N)
    FHP2(N)=FHP(N)
    CC 210 I=1.0NS
    C(N,I)=CS(N,I)
210 CM2(N,I)=CM(N,I)
    RS=RSSS
    RSM=RSM
    DELTAX=2.0*DELTAX
    X=X+DELTAX
    CC 1C 125
300 CC 320 N=1.0LP2
    IF(ABSF((UM2(N)-UM(N))/UM2(N))-FNDSSL) 310.310.400
310 IF(ABSF((FHP2(N)-FHP(N))/FHP2(N))-FNCSSL) 320.320.400
320 CC CONTINUE
    IF(I42) 341.325.325
325 CC 340 I=1.0NS
    CC 340 N=1.0LP2

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PAGE 3

SUBROUTINE STEPSZ

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330 IF(ABSF(CM2(N,I)-CM(N,I))/CM2(N,I))-FNDSSL) 340.340.400
340 CONTINUE
341 INCSS=1
342 IF(SENSE SWITCH 6) 343.346
343 PRINT 345.CELTAX.X
345 FORMAT(20H DELTAX INCREASED TO1PE15.8.7H X=1PE15.8)
346 CO 350 N=1.LP2
      U(N)=UP(N)
      FM(N)=FM(N)
      CO 350 I=1.NS
350 C(N,I)=CM(N,I)
352 CC 360 N=2.L
      IF(INCSS=1) 360.365.365
360 RSMRS=RS*RHQ(N)*UP1(N)*RS
      GC TC 370
365 RSMRS=RS*RHQ(N)*U(N)*RS
370 SIGNAL(N)=RSMRS*(A1L*FMUL(N)+A1T*(FMUT1P(N)+FMUT1M(N))*5)
      SIGMAH(N)=RSMRS*(A4L*FMUL(N)/PRAL(N)+A4T*(FMUT1P(N)+FMUT1M(N))*5/
      1PRAT(N))
      IF(A2) 3708.3705.3705
3705 SIGMAC(N)=RSMRS*(A3L*FMUL(N)+DKOL(N,1)/SCL(N)+A3T*.5*(FMUT1P(N)+FM
      1UT1P(N))*CKOT(N,1)/SCT(N))
3708 IF (SENSE SWITCH 2) 371.373
371 WRITE OUTPUT TAPE 6.372.N.SIGMAU(N).SIGMAC(N).SIGMAH(N)
372 FCRAI(5X13.1P3E13.5)
373 IF(SIGMAU(N)) 374.375.374
374 IF(DELTAX-DELTAP**2/2.0/SIGMAU(N)/1.00001) 375.375.485
375 IF(A2) 377.3755.3755
3755 IF(SIGMAC(N)) 376.377.376
376 IF(DELTAX-DELTAP**2/2.0/SIGMAC(N)/1.00001) 377.377.485
377 IF(SIGMAH(N)) 378.380.378
378 IF(DELTAX-DELTAP**2/2.0/SIGMAH(N)/1.00001) 380.380.485
380 CONTINUE
      JS=JS+1
385 CALL STAQUT(3)
390 NCCLN7=C
      JBYCTR=JBYCTR+2
      GC TC 130
400 CO 420 N=1.LP2
      IF(ABSF(UP2(N)-UP(N))/UP2(N))-FNDSSH) 410.410.470
410 IF(ABSF(FM2(N)-FM(N))/FM2(N))-FNDSSH) 420.420.470
420 CCNTINLE
      IF(-2) 445.425.425
425 CC 440 I=1.NS
      CO 440 N=1.LP2
430 IF(ABSF(CM2(N,I)-CM(N,I))/CM2(N,I))-FNDSSH) 440.440.470
440 CCNTINLE
445 INCSS=-1
      CELTAX=.5*CELTAX
      CC 460 N=1.LP2
      U(N)=UP2(N)
      FM(N)=FM2(N)
      CO 460 I=1.NS
      C(N,I)=CM2(N,I)
      RSM=RSM5
      GC TC 352

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SUBROUTINE STEPSZ

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470 IF(JBYCTR-JINPUT)445.445.500
485 IF(SENSE SWITCH 6)486.500
486 PRINT 450
490 FORMAT(5X22+STABILITY REQD HALVING)
500 IF(SENSE SWITCH 6)501.506
501 PRINT 505.DELTAX.X
505 FORMAT(20H DELTAX DEC TC 1/4 1PE15.8.7H X=1PE15.8)
506 ACCUN7=ACCUN7+1
507 IF(ACCUN7-7)507.600.600
507 DO 510 N=1.LP2
    U(N)=UP(N)
    FH(N)=FFM(N)
    DO 510 I=1.NS
    510 C(N,I)=CM(N,I)
    CALL STACLT(3)
    515 DO 520 N=1.LP2
    U(N)=US(N)
    FH(N)=FFS(N)
    DO 520 I=1.NS
    520 C(N,I)=CS(N,I)
    RS=RSSS
    X=X+.75*DELTAX
    DELTAX=.25*DELTAX
    INSTEP=1
    RETURN
600 PRINT 602
602 FORMAT(2X22+DELTA X HALVED 7 TIMES)
    PAUSE 603
    GC TC 515
    ENC(1.1.0.0.0.0.0.1.0.0.0.0.0.0.0.0)

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SUBROUTINE STEPSZ

DEC OCT
801 01441

STORAGE NOT USED BY PROGRAM

DEC OCT
23210 55252

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STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	A6T 32552 77450
A8T 32551 77447	A8T 32550 77446	A8T 32549 77445	A8T 32548 77444	A8T 32547 77443
A8T 32546 77442	AC12 32545 77441	AH12 32535 77427	ALPHA 32534 77426	ASR 32533 77425
AU12 32523 77413	B1T 32522 77412	B2T 32462 77316	B3T 32402 77222	B4T 32342 77126
B5T 32282 77032	B6T 32222 76736	B7T 32162 76642	B8T 32102 76546	B8T 32101 76545
B3T 32100 76544	B8T 32099 76543	B8T 32098 76542	B8T 32097 76541	B8T 32096 76540
B8T 32095 76537	BH12 32085 76525	BLOCK 32084 76524	BSR 32024 76430	BUI2 32014 76416
C12 31413 75265	CCALC 31353 75171	CC 31403 75253	CE 30753 74041	CM1 30143 72677
CM2 30133 72665	CM 30743 74027	CONAN 29533 71535	CPE 29531 71533	CP 29532 71534
C 32013 76415	CSR 28930 70402	CS 29530 71532	CSUB 23214 55256	DCDP12 28920 70370
DEL 28910 70356	DEL TAP 28909 70355	DEL TAX 28908 70354	DEL XOD 28907 70353	DEL XST 28906 70352
DN2 27703 66067	DNO 27701 66065	DO2 27700 66064	DKOT 28303 67217	DN2D02 27702 66066
EDENS 27697 66061	EPSIC 27636 65764	EPSIH 27635 65763	EPSI 27637 65765	EPSIT 27634 65762
EPSIU 27633 65761	ETA 27632 65760	FA 27631 65757	F8 27630 65756	FC 27629 65755
FEDA 27628 65754	FEDB 27627 65753	FEDC 27626 65752	FH12 27625 65751	FHCALC 27564 65654
FHE 27504 65560	FHM2 27443 65463	FHM 27503 65557	FH 27625 65751	FHS 27383 65367
FINO 27323 65273	FKPS1 27321 65271	FK 27322 65272	FLELIN 27260 65174	FLETIN 27259 65173
FLEWL 27258 65172	FLEMT 27198 65076	FLN2 27138 65002	FLNOD 27018 64612	FLNO 27078 64706
FLU2 26558 64516	FL 27261 65175	FM 26898 64422	FMUL12 26828 64314	FMUL 26808 64410
FMUTIM 26827 64313	FMUTIP 26767 64217	FNDSSH 26707 64123	FNDSSL 26706 64122	FNUREW 23215 55257
FNUREX 23216 55260	FSHE 26645 64025	FSH12 26044 62674	FSH 26644 64024	F3HP 26034 62662
FSH 26705 64121	FSKRA 26032 62660	FSKR8 26022 62646	FSKRD 26002 62662	FSKRD 26002 62662
FSKRE 26001 62621	FSKRF 26000 62620	FSKR8 25999 62617	FSME 25989 62605	FSME 25989 62605
FSMNOP 25986 62602	FSMNO 25987 62603	FSMN 25988 62604	GAMM 25984 62600	GAMM 25984 62600
HE 25983 62577	HH 25982 62576	IALT 25977 62571	INDCOO 25975 62567	INDCOO 25975 62567
INCLAS 25565 62555	INDPRI 25954 62542	INDP 25955 62543	INDR 25903 62457	INDR 25903 62457
INDSTP 25502 62456	INDSTR 25901 62455	INDTYP 25900 62454	JBYCTR 23211 55253	JBYCTR 23211 55253
JINPOT 25890 62442	JS 25889 62441	NS 25888 62440	LP2 25886 62436	L 25887 62437
UGIVEK 25881 62431	NPS1 25885 62435	NSR 25883 62433	NS 25864 62434	OGIVEH 25882 62432
PRAT 25809 62321	PE 25872 62420	PRALIN 25810 62322	PRAL 25870 62416	PRATIN 25749 62225
PRSAVE 25686 62126	PRDIRA 25748 62224	PRDS 25688 62130	PRP 25687 62127	PR 25871 62417
PS 25685 62125	P 25880 62430	PSCALC 25285 61305	PSI 25225 61211	PSITCU 25165 61115
REX 23218 55262	RHO12 25040 60720	RHOCAL 25101 61015	RHOE 25041 60721	REW 23217 55261
RHO2TG 25039 60717	RN 25038 60716	RNS 25037 60715	R 25143 61113	RSC 24986 60632
RSM 24985 60631	RS 24987 60633	SCHLIN 24984 60630	SCHTIN 24983 60627	SCL 24982 60626
SCT 24522 60532	SHANGL 24862 60436	SIGMAC 24861 60435	SIGMAU 24741 50245	SIGMAU 24741 50245
STADIS 24681 60151	TAUM 24620 60054	TAUP 24560 57760	TESTAT 24499 57653	THETAT 24499 57653
THPER 24458 57662	TIN 24497 57661	TITLE1 24496 57660	TITLE2 24484 57644	TITLE3 24472 57630
TM 24460 57614	T 24680 60150	TVN2 24400 57520	TWNOP 24398 57516	TWNO 24399 57517
TVO2 24397 57515	U12 24336 57420	UCALC 24335 57417	UE 24275 57323	UINF 24274 57322
ULOLIM 24273 57321	UM1 24212 57224	UM2 24152 57107	UM 24272 57320	U 24396 57514
US 24092 57034	WOT 24032 56740	XI 23431 55607	XL 23430 55606	XLS 23429 55605
Y 23376 55520	X 23452 55610	XS 23378 55522	XUI2 23377 55521	YCALC 23316 55424
Y 23376 55520	YTHC 23255 55327	YTH 23256 55330	YTHU 23245 55315	Z1L 23243 55313
Z1R 23242 55312	Z1 23244 55314	Z1S 23232 55300	Z2R 23230 55276	Z2 23231 55277

SUBROUTINE STEPSZ

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

INDSS	DEC	OCT		DEC	OCT		DEC	OCT	
RMS	800	01440	I	799	01437	N	797	01435	
	795	01433	RSS	794	01432			796	01434

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC		EFN	LOC		EFN	LOC	
81AN	119 01415	81A	345 01401	818K	372 01370	81FA	490 01365	
81IC	602 01347						81FP	505 01360

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT		DEC	OCT		DEC	OCT
1)	782 01416	2)	719 01317	3)	726 01326	6)	733 01335
C1100	787 01423	C1101	788 01424	C1200	789 01425	C1201	790 01426
C1203	792 01430	C1204	793 01431	O1132	611 01143	O1131	711 01307
D1400	132 00204	D1430	664 01230	O1600	131 00203	D1700	130 00202
E19	66 00102	E1E	85 00125	E1M	117 00165	E110	272 00420
E11J	304 00460	E12P	563 01063	E13D	666 01232	E11H	790 00442

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT		DEC	OCT		DEC	OCT
STAUT	0 00000	(FIL)	2 00002	(SPH)	1 00001	(STH)	3 00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

STAUT	(FIL)	(SPH)	(STH)
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	
50	16 00015	100	17 00021	105	25 00051	106	28 00065	108	29 00067
111	31 00107	112	33 00122	113	35 00136	114	36 00144	1142	38 00153
116	40 00171	1162	41 00173	118	42 00205	120	46 00232	125	47 00234
130	52 00250	200	57 00263	202	58 00265	205	62 00305	206	64 00317
210	71 00345	300	77 00370	310	79 00407	320	80 00424	325	82 00432
330	84 00447	340	85 00467	341	86 00476	343	88 00502	346	90 00511
350	94 00531	352	95 00541	360	97 00554	365	99 00564	370	100 00573
3705	103 00635	3708	104 00660	371	105 00662	373	107 00676	374	108 00700
375	109 00714	3755	110 00720	376	111 00722	377	112 00736	378	113 00740
380	114 00754	385	116 00765	390	117 00767	400	120 00775	410	122 01015
420	123 01031	425	125 01040	430	127 01052	440	128 01072	445	129 01103
460	135 01130	470	138 01144	485	139 01151	486	140 01153	500	141 01156
501	142 01160	506	144 01167	507	146 01176	510	150 01216	515	152 01235
520	156 01255	600	163 01310						

SUBROUTINE UCSTHE

SUBROUTINE UCSTRE

COMMON ALC,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AM12,ALPHA,ASR,AU12,B01T,B2T,B3T,
B4B4T,B5T,B6T,B7T,B8B1T,B8B2T,B8B3T,B8B4T,B8B5T,B8B6T,B8B7T,B8B12,
B8B8BLOCK,B8B9,AU12,C,C12,C2C,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
DC4C5R,DCDP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
D0K0T,DN2,DN2002,DNQ,D02,DSCTIP,DUDP12,E0ENS,EPSI,
EPSTU,EPSTU,ETA,FA,FB,FC,FEDA,FEDB,
F7EDC,FH,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FINU,FK,KFKPSI,FL,FLELIN,FLETL,FLEWL,FLEMT,
FLEN2,FMLN,FMLUP,FLC2,FM,FML,FML12,FMLTIN,FMLTIP,FNDSSH,
FNDPNDSSL,FSH,FSH2,FSH3,FSH4,FSH5,FSH6,FSH7,FSH8,FSH9,FSH12,FSP,
FSK,FSKRA,FSKRB,FSKRC,FSKRD,
FBSKRE,FSKRF,FSKRR,FSE,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
IALT,IDEI,INDCOC,INDLAS,INDP,INDPRI,INDPS,INDR,
INDSTP,INDSTR,INDTYP,INPUT,JS,KS,L,L2,MPSI,NS,NSR,
OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PRDIRA
COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QW,R,RESTAR,RMO,
RRHOCAL,RHOE,RHO12,RHOSGT,RRN,RNS,RS,RSC,RSN,RSCHLIN,SCHTIN,
SSCL,SCI,SHANGL,SIGMAC,SIGMAH,SIGMAU,
SSSTADIS,T,TAUM,TAUP,TESTRA,THEAT,THPER,TIN,
THITLE1,TITLE2,TITLE3,TM,TVN2,
TVNO,TVMOP,TV02,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
SUM2,US,XDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
YTHYU,Z1,Z12,Z1R,Z1S,Z2,Z2R,Z2S
COMMON REIET,REX,REW,FNUREX,FNUREW,CSUB,I,PRINT,NCOUNT,JBYCTR
L,F,SH12,T12,Y12,STRLL,STRUL

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DIMENSION AC12(10),ASR(10),BIT(60),B2T(60),B3T(60),B4T(60),B5T(60),
B6T(60),B7T(60),B8T(12(10),BLCK(60),BSR(10),C(60,10),C12(10),
CC2(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
DC2C(2(60,10),ES(60),CSR(10),OCDP12(10),DKDL(60,10),DKDT(60,10),
DEGENS(60),FH(60),FHCLC(60),FHM(60),FHM2(60),FHS(60),
FSPKPSI(60),FLEWL(60),FLEMT(60),FLN2(60),FLNO(60),
FBNLQNP(60),FLO2(60),FM(10),FMUL(60),FMUTIM(60)
DIMENS(UH FMUTIP(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
FESKRAS(10),FSKRC(10),FSKRP(10),MH(5),INDCOO(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PROIRA(60),
BPRAL(60),PRAT(60),PS18,50),PSCALC(60),PSI(60),RHO(60),
MRHOAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUH(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
UWDT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
ZZR(10)

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1 IF(INO$TR) 5000.50,2
2 GO TO (3,4,5,3,5),INOR
3 THE$AT=1.5707963-(ALPHA+XRN)
4 GO TO 7
5 THE$AT=CON$AN
6 GO TO 7
7 THE$AT=0.0
8 IF(EPSI) 0,9,10
9 TWOPI=1.0
10 RS1PE=RS

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SUBROUTINE UCSTRE

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GO TO 12
10 TWOPI=6.2831853
   RSIME=1.0
12 FMBL=0.0
   DO 15 N=2,4
15 FMBL=FMBL+2.0*Y(N)
   FMBL=(FMBL+Y(1)-Y(4))*TWOPI*COSE(THETAT)*DELTAP/RS+TWOPI*RSIME*PSI
   I(L)
   DIN2=SQRT(FMBL/RHDE/UINF/3.1415926)
   IF(DIN2-RS) 19,19,16
16 PRINT 17,DIN2,RS,FMBL,THETAT
17 FORMAT(7H DIN2=1PE13.5,4HRS =1PE13.5,1P2E13.5)
   DIN2=.9*RS
19 DO 20 N=1,10
   IF(DIN2-ZZK(N))25,25,20
20 CONTINUE
   STOP 21
25 IF(INDTYP(1)-1)29,26,29
26 ZIA=0.0
   THETA=1.5707963
   GO TO 40
29 IF(INDTYP(N)-6)30,35,35
30 ZIA=(DIN2-BSR(N))/ASR(N)
   THETA=ATANF(ASR(N))
   GO TO 40
35 ZIA=ASR(N)+BSR(N)*(DIN2-CSR(N))*2
   THETA=ATANF(.5/BSR(N)/(DIN2-CSR(N)))
40 DIST=SQRT(ZIA-21)*2+(DIN2-22)*2
   FMI=UINF/49.9/SQRTF(1.8*FSHE/CPE)
   PROS=PE*(2.0*GAMM*(FMI*SINF(THETA))*2-GAMM+1.0)/(GAMM+1.0)
   UDS=SQRTF(1.0-(4.0*(FMI*2*(SINF(THETA))*2-1.0)*(GAMM*(FMI*SINF
   1(THETA))*2+1.0))/(GAMM+1.0)*2*FMI*2*(SINF(THETA))*2))*UINF
   SCOMP=(21-ZIA)/DIST
   UESTAR=UDS
42 WRITE OUTPUT TAPE 6,42,THETA,PROS,ZIA,DIN2,UDS
   IN DIN2=1PE13.5,6H UDS=1PE13.5)
   GO TO 52
50 UESTAR=UE
52 NCOUNT=0
55 WRITE OUTPUT TAPE 6,55
   FORMAT(6X3HXD10X4HZ10010X1HUI1X4HC(N)8X5HC(M)8X6HC(MD)8X5HC(E-))
   110X1MT11X3HRNO10X2HNE/,)
   K=1
   IF(INDSTR) 5555,56,58
56 X00=X5+DELXST
   GO TO 60
58 X00=DELXST
   Z100=ZIA+SCOMP*DELXST
60 U(L+3)=UESTAR
   DO 65 I=1,NS
65 C(L+3,I)=CE(I)
   FMI(L+3)=FMI
   PSI(L+3)=PSI(L+2)+DELTAP
70 INDF00=-1
   DELX00=DELXST

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100 CALL PRTERH(XDD,L+3,L+3,K)
   IF(A2) IC05,I005,I003
1003 CALL WDOTRT(L+3,L+3)
1005 US(L+3)=U(L+3)
   UM1(L+3)=U(L+3)-PRP/RHO(L+3)*DELXDD/U(L+3)
   U(L+3)=UM1(L+3)
   DO 1020 I=1,NS
     CS(L+3,I)=C(L+3,I)
     CM1(I) =C(L+3,I)+DELXDD*WDOT(L+3,I)/U(L+3)/RHO(L+3)
1020 C(L+3,I)=CM1(I)
     XDD=XDD+DELXDD
     IF(INDSTR)5555,1022,1021
1021 Z100=Z100+SCOMP*DELXDD
1022 CALL PRTERH(XDD,L+3,L+3,K)
   IF(A2) 1025,1025,1023
1023 CALL WDOTRT(L+3,L+3)
1025 UM2(L+3)=U(L+3)-PRP/RHO(L+3)*DELXDD/U(L+3)
   U(L+3)=US(L+3)
   DO 2030 I=1,NS
     CM2(L+3,I)=C(L+3,I)+DELXDD*WDOT(L+3,I)/U(L+3)/RHO(L+3)
2030 C(L+3,I)=CS(L+3,I)
     DELXDD=2.0*DELXDD
     CALL PRTERH(XDD,L+3,L+3,K)
   IF(A2) 2035,2035,2033
2033 CALL WDOTRT(L+3,L+3)
2035 UM(L+3)=U(L+3)-PRP/RHO(L+3)*DELXDD/U(L+3)
   DO 2040 I=1,NS
     CM(L+3,I)=C(L+3,I)+DELXDD*WDOT(L+3,I)/U(L+3)/RHO(L+3)
2040 IF(ABSF(UM2(L+3)-UM(L+3))/UM2(L+3))-FNDSSL)2050,2050,2070
2050 IF(A2) 2065,2052,2052
2052 DO 2060 I=1,NS
   IF(ABSF(CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNDSSL)2060,2060,2070
2060 CONTINUE
2065 IND22=C
   GO TO 2110
2070 IF(ABSF(UM2(L+3)-UM(L+3))/UM2(L+3))-FNDSSH)2080,2080,2100
2080 IF(A2) 2095,2082,2082
2082 DO 2090 I=1,NS
   IF(ABSF(CM2(L+3,I)-CM(L+3,I))/CM2(L+3,I))-FNDSSH)2090,2090,2100
2090 CONTINUE
2095 IND22=1
   GO TO 2110
2100 XDD=XDD-.75*DELXDD
   IND22=-1
   IF(INDSTR) 5555,2105,2103
2103 Z100=Z100-.75*DELXDD*SCOMP
2105 DELXDD=.25*DELXDD
   GO TO 100
2110 IF(INDSTR)5555,2120,2115
2115 IF(Z100+SCOMP*DELXDD-Z11)2150,2130,2130
2120 IF(XDD*DELXDD-X) 2145,2130,2130
2130 UM(L+3)=UM1(L+3)
   DO 2140 I=1,NS
     CM(L+3,I)=CM1(I)
     XDD=XDD-.5*DELXDD
   IF(INDSTR) 5555,2143,2141

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SURROUTINE UCSTRE

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2141 2100-2100-.5*DELX00*SCOMP
2143 DELX00=0.5*DELX00
GO TO 2500
2145 IF(X00-DELX00-XLS(K)) 2150,2130,2130
2150 IF(IND22) 2500,2500,2170
2170 UM(L+3)=UM2(L+3)
DO 2180 I=1,NS
2180 CM(L+3,I)=CM2(L+3,I)
DELX00=0.5*DELX00
2500 IF(UM(L+3)-ULOLIM)2505,2510,2510
2505 UM(L+3)=ULOLIM
2510 IF(IND22) 3060,2000,3060
2600 FNE=RHD(L+3)*CM(L+3,7)*5.664696E26
WRITE OUTPUT TAPE 6,3005,X00,2100,UM(L+3),(CM(L+3,I),I=4,NS),T(L+3
),RHD(L+3),FNE
3005 FORMAT (1H,1P10E13.5)
3060 IF(INDSTR) 5555,3109,3460
3109 IF(K-KS)3120,3110,3110
3110 IF(ABSF(X00-XI)-.01*DELX00)3500,3500,3115
3115 IF(X00-X)3120,3500,3610
3120 XC=X00+DELX00
3123 U(L+3)=UM(L+3)
DO 3125 I=1,NS
3125 C(L+3,I)=CM(L+3,I)
IF(INDSTR) 5555,3140,3130
3130 2100-2100+DELX00*SCOMP
GO TO 100
3140 IF(INDFOO)3150,3450,3400
3150 IF(ABSF(X00-XLS(K))-0.01*DELX00)3200,3200,3155
3155 IF(X00-XLS(K)) 100,3200,3300
3200 INDFOO=0
GO TO 100
3300 DELX00=DELX00-(X00-XLS(K))
X00=XLS(K)
INDFOO=1
GO TO 100
3400 X00=X00-DELX00*DELXST
3450 K=K+1
GO TO 70
3460 IF(ABSF(2100-211)-.01*DELX00*SCOMP)3500,3500,3470
3470 IF(2100-211)3120,3500,3620
3500 IF(A2) 3510,3520,3520
3510 CALL CEQGE(9,L+3,L+3)
3520 RETURN
3610 DELX00=DELX00-(X00-X)
X00=X
GO TO 4000
3620 DELX00=DELX00-(2100-211)/SCOMP
X00=X00-(2100-211)/SCOMP
2100=211
4000 CALL PRTERH(X00,L+3,L+3,K)
IF(A2) 4030,4035,4033
4030 CALL WOOTR(L+3,L+3)
4035 UM(L+3)=U(L+3)-PRP/RHD(L+3)*DELX00/U(L+3)
DO 4040 I=1,NS
4040 CM(L+3,I)=C(L+3,I)+DELX00*WOOT(L+3,I)/U(L+3)/RHD(L+3)

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4500 IF(UM(L+3)-ULOLIM)4505,4510,4510
4505 UM(L+3)=ULOLIM
4510 FNE=RHO(L+3)*CM(L+3,7)*5.664696E26
      WRITE OUTPUT TAPE 6,3005,X00,Z100,UM(L+3),(CM(L+3,1),I=4,NS),T(L+3
      1),RHO(L+3),FNE
      GO TO 3500
5000 UM(L+3)=UE
      DO 5010,I=1,NS
5010 CM(L+3,I)=CE(I)
      FM(L+3)=FME
      PSI(L+3)=PSI(L+2)+DELTAP
      RETURN
5555 STOP 5555
      END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)

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SUBROUTINE UCSTRE

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STORAGE NOT USED BY PROGRAM

 DEC DCT
 1131 02153

 DEC DCT
 23205 55245

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC DCT	DEC DCT	DEC DCT	DEC DCT	DEC DCT	DEC DCT	DEC DCT	DEC DCT
A1L 32561 77461	A1T 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455	A4L 32556 77454	A4T 32555 77453	A5L 32554 77452
A6L 32551 77447	A6T 32550 77446	A8L 32549 77445	A8T 32548 77444	A8T 32547 77443	A9L 32546 77442	A9T 32545 77441	A10L 32544 77440
A11L 32541 77437	A11T 32540 77436	B1L 32539 77435	B1T 32538 77434	B1T 32537 77433	B2L 32536 77432	B2T 32535 77431	B3L 32534 77430
B4L 32531 77427	B4T 32530 77426	B5L 32529 77425	B5T 32528 77424	B5T 32527 77423	B6L 32526 77422	B6T 32525 77421	B7L 32524 77420
B8L 32521 77417	B8T 32520 77416	B9L 32519 77415	B9T 32518 77414	B9T 32517 77413	B10L 32516 77412	B10T 32515 77411	B11L 32514 77410
B12L 32511 77407	B12T 32510 77406	B13L 32509 77405	B13T 32508 77404	B13T 32507 77403	B14L 32506 77402	B14T 32505 77401	B15L 32504 77400
B16L 32501 77397	B16T 32500 77396	B17L 32499 77395	B17T 32498 77394	B17T 32497 77393	B18L 32496 77392	B18T 32495 77391	B19L 32494 77390
B20L 32491 77387	B20T 32490 77386	B21L 32489 77385	B21T 32488 77384	B21T 32487 77383	B22L 32486 77382	B22T 32485 77381	B23L 32484 77380
B24L 32481 77377	B24T 32480 77376	B25L 32479 77375	B25T 32478 77374	B25T 32477 77373	B26L 32476 77372	B26T 32475 77371	B27L 32474 77370
B28L 32471 77367	B28T 32470 77366	B29L 32469 77365	B29T 32468 77364	B29T 32467 77363	B30L 32466 77362	B30T 32465 77361	B31L 32464 77360
B32L 32461 77357	B32T 32460 77356	B33L 32459 77355	B33T 32458 77354	B33T 32457 77353	B34L 32456 77352	B34T 32455 77351	B35L 32454 77350
B36L 32451 77347	B36T 32450 77346	B37L 32449 77345	B37T 32448 77344	B37T 32447 77343	B38L 32446 77342	B38T 32445 77341	B39L 32444 77340
B40L 32441 77337	B40T 32440 77336	B41L 32439 77335	B41T 32438 77334	B41T 32437 77333	B42L 32436 77332	B42T 32435 77331	B43L 32434 77330
B44L 32431 77327	B44T 32430 77326	B45L 32429 77325	B45T 32428 77324	B45T 32427 77323	B46L 32426 77322	B46T 32425 77321	B47L 32424 77320
B48L 32421 77317	B48T 32420 77316	B49L 32419 77315	B49T 32418 77314	B49T 32417 77313	B50L 32416 77312	B50T 32415 77311	B51L 32414 77310
B52L 32411 77307	B52T 32410 77306	B53L 32409 77305	B53T 32408 77304	B53T 32407 77303	B54L 32406 77302	B54T 32405 77301	B55L 32404 77300
B56L 32401 77297	B56T 32400 77296	B57L 32399 77295	B57T 32398 77294	B57T 32397 77293	B58L 32396 77292	B58T 32395 77291	B59L 32394 77290
B60L 32391 77287	B60T 32390 77286	B61L 32389 77285	B61T 32388 77284	B61T 32387 77283	B62L 32386 77282	B62T 32385 77281	B63L 32384 77280
B64L 32381 77277	B64T 32380 77276	B65L 32379 77275	B65T 32378 77274	B65T 32377 77273	B66L 32376 77272	B66T 32375 77271	B67L 32374 77270
B68L 32371 77267	B68T 32370 77266	B69L 32369 77265	B69T 32368 77264	B69T 32367 77263	B70L 32366 77262	B70T 32365 77261	B71L 32364 77260
B72L 32361 77257	B72T 32360 77256	B73L 32359 77255	B73T 32358 77254	B73T 32357 77253	B74L 32356 77252	B74T 32355 77251	B75L 32354 77250
B76L 32351 77247	B76T 32350 77246	B77L 32349 77245	B77T 32348 77244	B77T 32347 77243	B78L 32346 77242	B78T 32345 77241	B79L 32344 77240
B80L 32341 77237	B80T 32340 77236	B81L 32339 77235	B81T 32338 77234	B81T 32337 77233	B82L 32336 77232	B82T 32335 77231	B83L 32334 77230
B84L 32331 77227	B84T 32330 77226	B85L 32329 77225	B85T 32328 77224	B85T 32327 77223	B86L 32326 77222	B86T 32325 77221	B87L 32324 77220
B88L 32321 77217	B88T 32320 77216	B89L 32319 77215	B89T 32318 77214	B89T 32317 77213	B90L 32316 77212	B90T 32315 77211	B91L 32314 77210
B92L 32311 77207	B92T 32310 77206	B93L 32309 77205	B93T 32308 77204	B93T 32307 77203	B94L 32306 77202	B94T 32305 77201	B95L 32304 77200
B96L 32301 77197	B96T 32300 77196	B97L 32299 77195	B97T 32298 77194	B97T 32297 77193	B98L 32296 77192	B98T 32295 77191	B99L 32294 77190
B100L 32291 77187	B100T 32290 77186	B101L 32289 77185	B101T 32288 77184	B101T 32287 77183	B102L 32286 77182	B102T 32285 77181	B103L 32284 77180
B104L 32281 77177	B104T 32280 77176	B105L 32279 77175	B105T 32278 77174	B105T 32277 77173	B106L 32276 77172	B106T 32275 77171	B107L 32274 77170
B108L 32271 77167	B108T 32270 77166	B109L 32269 77165	B109T 32268 77164	B109T 32267 77163	B110L 32266 77162	B110T 32265 77161	B111L 32264 77160
B112L 32261 77157	B112T 32260 77156	B113L 32259 77155	B113T 32258 77154	B113T 32257 77153	B114L 32256 77152	B114T 32255 77151	B115L 32254 77150
B116L 32251 77147	B116T 32250 77146	B117L 32249 77145	B117T 32248 77144	B117T 32247 77143	B118L 32246 77142	B118T 32245 77141	B119L 32244 77140
B120L 32241 77137	B120T 32240 77136	B121L 32239 77135	B121T 32238 77134	B121T 32237 77133	B122L 32236 77132	B122T 32235 77131	B123L 32234 77130
B124L 32231 77127	B124T 32230 77126	B125L 32229 77125	B125T 32228 77124	B125T 32227 77123	B126L 32226 77122	B126T 32225 77121	B127L 32224 77120
B128L 32221 77117	B128T 32220 77116	B129L 32219 77115	B129T 32218 77114	B129T 32217 77113	B130L 32216 77112	B130T 32215 77111	B131L 32214 77110
B132L 32211 77107	B132T 32210 77106	B133L 32209 77105	B133T 32208 77104	B133T 32207 77103	B134L 32206 77102	B134T 32205 77101	B135L 32204 77100
B136L 32201 77097	B136T 32200 77096	B137L 32199 77095	B137T 32198 77094	B137T 32197 77093	B138L 32196 77092	B138T 32195 77091	B139L 32194 77090
B140L 32191 77087	B140T 32190 77086	B141L 32189 77085	B141T 32188 77084	B141T 32187 77083	B142L 32186 77082	B142T 32185 77081	B143L 32184 77080
B144L 32181 77077	B144T 32180 77076	B145L 32179 77075	B145T 32178 77074	B145T 32177 77073	B146L 32176 77072	B146T 32175 77071	B147L 32174 77070
B148L 32171 77067	B148T 32170 77066	B149L 32169 77065	B149T 32168 77064	B149T 32167 77063	B150L 32166 77062	B150T 32165 77061	B151L 32164 77060
B152L 32161 77057	B152T 32160 77056	B153L 32159 77055	B153T 32158 77054	B153T 32157 77053	B154L 32156 77052	B154T 32155 77051	B155L 32154 77050
B156L 32151 77047	B156T 32150 77046	B157L 32149 77045	B157T 32148 77044	B157T 32147 77043	B158L 32146 77042	B158T 32145 77041	B159L 32144 77040
B160L 32141 77037	B160T 32140 77036	B161L 32139 77035	B161T 32138 77034	B161T 32137 77033	B162L 32136 77032	B162T 32135 77031	B163L 32134 77030
B164L 32131 77027	B164T 32130 77026	B165L 32129 77025	B165T 32128 77024	B165T 32127 77023	B166L 32126 77022	B166T 32125 77021	B167L 32124 77020
B168L 32121 77017	B168T 32120 77016	B169L 32119 77015	B169T 32118 77014	B169T 32117 77013	B170L 32116 77012	B170T 32115 77011	B171L 32114 77010
B172L 32111 77007	B172T 32110 77006	B173L 32109 77005	B173T 32108 77004	B173T 32107 77003	B174L 32106 77002	B174T 32105 77001	B175L 32104 77000
B176L 32101 76997	B176T 32100 76996	B177L 32099 76995	B177T 32098 76994	B177T 32097 76993	B178L 32096 76992	B178T 32095 76991	B179L 32094 76990
B180L 32091 76987	B180T 32090 76986	B181L 32089 76985	B181T 32088 76984	B181T 32087 76983	B182L 32086 76982	B182T 32085 76981	B183L 32084 76980
B184L 32081 76977	B184T 32080 76976	B185L 32079 76975	B185T 32078 76974	B185T 32077 76973	B186L 32076 76972	B186T 32075 76971	B187L 32074 76970
B188L 32071 76967	B188T 32070 76966	B189L 32069 76965	B189T 32068 76964	B189T 32067 76963	B190L 32066 76962	B190T 32065 76961	B191L 32064 76960
B192L 32061 76957	B192T 32060 76956	B193L 32059 76955	B193T 32058 76954	B193T 32057 76953	B194L 32056 76952	B194T 32055 76951	B195L 32054 76950
B196L 32051 76947	B196T 32050 76946	B197L 32049 76945	B197T 32048 76944	B197T 32047 76943	B198L 32046 76942	B198T 32045 76941	B199L 32044 76940
B200L 32041 76937	B200T 32040 76936	B201L 32039 76935	B201T 32038 76934	B201T 32037 76933	B202L 32036 76932	B202T 32035 76931	B203L 32034 76930
B204L 32031 76927	B204T 32030 76926	B205L 32029 76925	B205T 32028 76924	B205T 32027 76923	B206L 32026 76922	B206T 32025 76921	B207L 32024 76920
B208L 32021 76917	B208T 32020 76916	B209L 32019 76915	B209T 32018 76914	B209T 32017 76913	B210L 32016 76912	B210T 32015 76911	B211L 32014 76910
B212L 32011 76907	B212T 32010 76906	B213L 32009 76905	B213T 32008 76904	B213T 32007 76903	B214L 32006 76902	B214T 32005 76901	B215L 32004 76900
B216L 32001 76897	B216T 32000 76896	B217L 31999 76895	B217T 31998 76894	B217T 31997 76893	B218L 31996 76892	B218T 31995 76891	B219L 31994 76890
B220L 31991 76887	B220T 31990 76886	B221L 31989 76885	B221T 31988 76884	B221T 31987 76883	B222L 31986 76882	B222T 31985 76881	B223L 31984 76880
B224L 31981 76877	B224T 31980 76876	B225L 31979 76875	B225T 31978 76874	B225T 31977 76873	B226L 31976 76872	B226T 31975 76871	B227L 31974 76870
B228L 31971 76867	B228T 31970 76866	B229L 31969 76865	B229T 31968 76864	B229T 31967 76863	B230L 31966 76862	B230T 31965 76861	B231L 31964 76860
B232L 31961 76857	B232T 31960 76856	B233L 31959 76855	B233T 31958 76854	B233T 31957 76853	B234L 31956 76852	B234T 31955 76851	B235L 31954 76850
B236L 31951 76847	B236T 31950 76846	B237L 31949 76845	B237T 31948 76844	B237T 31947 76843	B238L 31946 76842	B238T 31945 76841	B239L 31944 76840
B240L 31941 76837	B240T 31940 76836	B241L 31939 76835	B241T 31938 76834	B241T 31937 76833	B242L 31936 76832	B242T 31935 76831	B243L 31934 76830
B244L 31931 76827	B244T 31930 76826	B245L 31929 76825	B245T 31928 76824	B245T 31927 76823	B246L 31926 76822	B246T 31925 76821	B247L 31924 76820
B248L 31921 76817	B248T 31920 76816	B249L 31919 76815	B249T 31918 76814	B249T 31917 76813	B250L 31916 76812	B250T 31915 76811	B251L 31914 76810
B252L 31911 76807	B252T 31910 76806	B253L 31909 76805	B253T 31908 76804	B253T 31907 76803	B254L 31906 76802	B254T 31905 76801	B255L 31904 76800
B256L 31901 76797	B256T 31900 76796	B257L 31899 76795	B257T 31898 76794	B257T 31897 76793	B258L 31896 76792	B258T 31895 76791	

SUBROUTINE UCSTRE

PAGE 7

21R 23242 55312 21 23244 55314 21S 23232 55300 22R 23230 55276 22 23231 55277
 22S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
DIM2	1130 02152	FM1	1129 02151	FM8L	1126 02150	FNE	1127 02147
INDF00	1125 02145	I	1124 02144	K	1123 02143	N	1122 02142
SCOMP	1120 02140	THETA	1119 02137	TWOPT	1118 02136	UDS	1117 02135
X00	1115 02133	Z1A	1114 02132	Z10C	1113 02131		

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC
811A	17 02102	811A	42 02073	811N	55 02053

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
I1	1091 02103	21	1022 01776	31	1030 02066	61	1045 02025
C1G0	1103 02117	C1G3	1104 02120	C1G5	1105 02121	C1100	1106 02122
C1200	1108 02124	C1201	1109 02125	C1202	1110 02126	C1203	1111 02127
D1110	615 01147	D121T	611 01143	D122A	696 01270	D131T	610 01142
D1430	946 01662	D161M	575 01077	D163D	945 01661	E13	39 00047
E16	50 00062	E1C	121 00171	E1E	129 00210	E1G	136 00210
E1L	157 00235	E1D	323 00503	E1R	344 00530	E11	385 00601
E117	450 00702	E11R	503 00767	E11G	549 01045	E111	563 01063
E11G	602 01132	E123	649 01211	E127	676 01244	E12F	719 01317
E12L	766 01376	E136	874 01552	E139	894 01576	E12K	761 01371
E113M	1019 01773	E123M	1019 01773	E133M	1019 01773	E12A	495 01267
						E1535	870 01546

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	QCT	DEC	QCT	DEC	QCT	DEC	QCT
ATAN	4 00004	CEGE	9 00011	COS	0 00000	OE	7 00007
SQRT	1 00001	W00TRT	8 00010	(FIL)	3 00003	PRTRM	2 00002

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ATAN	CEGE	COS	PRTRM	SIN	SQRT	W00TRT	(FIL)	(SPH)	(STH)
EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	IFN
2	15 00014	3	16 00041	4	18 00050	5	20 00054	7	21 00056
9	22 00063	10	25 00070	12	27 00074	15	29 00101	16	33 00152
19	36 00172	20	38 00211	25	40 00216	26	41 00224	29	44 00231
30	45 00236	35	48 00250	40	50 00277	50	59 00504	52	60 00506
56	64 00524	58	66 00531	60	68 00537	65	70 00545	70	73 00557
100	75 00563	1003	77 00602	1005	78 00610	1020	84 00642	1021	87 00656
1022	88 00664	1023	90 00703	1025	91 00711	1030	95 00741	1033	99 00770
2035	100 01000	2040	102 01016	2050	104 01041	2052	105 01046	2060	107 01070
2065	108 01073	2070	110 01101	2080	111 01111	2082	112 01115	2090	114 01137
2095	115 01144	2100	117 01150	2103	120 01163	2105	121 01172	2110	123 01176
2115	124 01202	2120	125 01212	2130	126 01220	2140	128 01226	2141	131 01245

SUBROUTINE UCSTRE

2143	132	01254
2500	140	01313
3109	151	01377
3125	157	01435
3200	164	01476
3470	174	01541
3620	182	01577
4500	191	1676
5555	208	01774

2145
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3500
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4505

134 01260
141 01320
152 01404
159 01446
166 01501
175 01547
185 01617
192 01702

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135 01271
142 01322
153 01416
161 01453
170 01513
176 01553
187 01635
193 01704

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143 01326
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162 01456
171 01517
177 01562
188 01643
201 01747

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138 01303
150 01372
155 01427
163 01471
173 01525
179 01566
190 01663
203 01755

PAGE 8

2143	132	01254
2500	140	01313
3109	151	01377
3125	157	01435
3200	164	01476
3470	174	01541
3620	182	01577
4500	191	1676
5555	208	01774

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179 01566
190 01663
203 01755

PAGE 1

SUBROUTINE UEDGE(J)

SUBROUTINE UEDGE(J)

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COMMON AIL,A11,A2,A3L,A3T,A4L,A4T,A5L,A5T,A6T,A6T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,ALPHA,ASR,AU12,B1T,B2T,E3T,
284T,B5T,B6T,B7T,B8T,882T,883T,884T,885T,886T,887T,8C12,8H12,
3BLDCK,BSR,BU12,C,C12,CC,CALC,CE,CM,CM1,CM2,COMEAN,CP,CPE,CS,
4CSR,DCOP12,DEL,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,DELTA,
5OKD1,DN2,DN2D02,DNC,D02,DSCRIP,DUOP12,EDENS,EPSI,
6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FE08,
7FEDC,FM,FH12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FMD,FK,FKPSI,FL,FLELIN,FLEML,FLEWT,
1FLN2,FLNO,FLNOP,FLC2,FM,FML,FML12,FMLTIP,FNDSSM,
2FNUSSL,FSH,FSHE,FSH1,FSH12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMH,FSMND,FSMNDP,FSMD,GAMM,HE,
4HH,IALT,IDEL,INDCOG,INDLAS,INOP,INDPRI,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,JINPUY,JS,KS,L,LP2,NPSI,NS,NSR,
6OGIVEH,OGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIM,PROIRA
COMMON PRDS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RHD,
1RHOCAL,RHDE,RHOL2,RHOSIG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIM,
2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
3SYADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVND,TVNOP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
6UM2,US,WDD1,X,XI,XL,XLS,XRM,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REW,FNUREX,FNUREN,CSU8,IPRINT,NCDUNT,JBYCTR

DIMENSION AC12(10),ASR(10),B1T(60),B2T(60),B3T(60),B4T(60),B5T(60),
1,B6T(60),B7T(60),B8T(60),BLDCK(60),BSR(10),C(60,10),C12(10),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCOP12(10),DKOL(60,10),DKOT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEML(60),FLENT(60),FLN2(60),FLND(60),
6FLNOP(60),FLD2(60),FM(10),FMUL(60),FMUTIM(60)
DIMENSION FMUTIP(60),FSH(60),FSH1(60,10),FSH12(10),FSKRA(10),
1FSKRB(10),FSKRC(10),FSKRK(10),HM(5),INDCOG(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PROIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHD(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UM1(60),UM2(60),US(60),
1WDD1(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

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UEDGE(1) IS UHALL

```

J=J
1F(J-1)3C,20,40
2U UM(1)=0.0
RETURN
3 STOP 30
4 1F(J-3)100,200,50
5 STOP 50
10 UM(L)=U(L)-PRP/RHD(L)*DELTA/U(L)
RETURN

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PAGE 2

SUBROUTINE UEDGE(J)

```
200 UM(L+1)=U(L+1)-PRP/RHO(L+1)*DELTA X/U(L+1)
   UM(L+2)=U(L+2)-PRP/RHO(L+2)*DELTA X/U(L+2)
   RETURN
   END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)
```

SUBROUTINE UEDGE(JJ)

PAGE 3

STORAGE NOT USED BY PROGRAM

DEC OCT
80 00120

DEC OCT
23210 55252

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

AIL 32561 77461	AIT 32560 77460	A2 32559 77457	A3L 32558 77456	A3T 32557 77455
A4L 32556 77454	A4T 32555 77453	A5L 32554 77452	A5T 32553 77451	A61T 32552 77450
AB2T 32551 77447	AB3T 32550 77446	AB4T 32549 77445	AB5T 32548 77444	AB6T 32547 77443
AB7T 32546 77442	AC12 32545 77441	AM12 32535 77427	ALPHA 32534 77426	ASR 32533 77425
AU12 32523 77413	AIT 32522 77412	B2T 32462 77316	B3T 32402 77222	B4T 32342 77126
B5T 32282 77032	B6T 32222 76736	B7T 32162 76642	B81T 32102 76546	B82T 32101 76545
B83T 32100 76544	B84T 32099 76543	B85T 32098 76542	B86T 32097 76541	B87T 32096 76540
BC12 32095 76537	BH12 32085 76525	BLOCK 32084 76524	B8R 32024 76430	BUI2 32014 76416
C12 31413 75265	CCALC 31353 75171	CC 31403 75253	CE 30753 74041	CM1 30143 72677
CM2 30133 72665	CM 30743 74027	COMEN 29533 71535	CPE 29531 71533	CP 29532 71534
C 32013 76415	CSR 28930 70402	CS 29530 71532	CSUB 23214 55256	DCDP12 28920 70370
DEL 28910 70356	DELTAP 28909 70355	DELTAX 28908 70354	DELX00 28907 70353	DELXST 28906 70352
OHDP12 28905 70351	OIST 28904 70350	OKOL 28903 70347	OKOT 28303 67217	DN2002 27702 66066
DN2 27703 66067	DN0 27701 66065	DO2 27700 66064	OSCRIP 27699 66063	DUOP12 27698 66062
EDENS 27697 66061	EPSIC 27636 65764	EPSIM 27635 65763	EPSI 27637 65765	EPSIT 27634 65762
EPSIU 27633 65761	ETA 27632 65760	FA 27631 65757	F8 27630 65756	FC 27629 65755
FEDA 27628 65754	FEDR 27627 65753	FEDC 27626 65752	FH12 27565 65655	FHCALC 27564 65654
FHE 27504 65560	FHM2 27443 65463	FHM 27503 65557	FH 27625 65751	FHS 27383 65367
FINO 27323 65273	FKPSI 27321 65271	FK 27322 65272	FLELIN 27260 65174	FLETIN 27259 65173
FLEWL 27258 65172	FLEWT 27198 65076	FLN2 27138 65002	FLMOP 27018 64612	FLND 27078 64706
FLO2 26958 64516	FL 27261 65175	FM 26898 64422	FMUL12 26828 64314	FMUL 26888 64410
FMUTIN 26827 64313	FMUTIP 26761 64217	FNOSSH 26707 64123	FNDSSL 26706 64122	FMUREN 23215 55257
FNUREX 23216 55260	FSME 26645 64025	FSH12 26044 62674	FSHP 26034 62662	FSMR 26002 62622
FSH 26705 64121	FSKRA 26032 62660	FSKRK 26022 62646	FSME 25989 62605	FSME 25989 62605
FSKRE 26001 62621	FSKRF 26000 62620	FSKRK 25999 62617	GAMM 25984 62600	GAMM 25984 62600
FSHROP 25986 62602	FSMNO 25987 62603	FSMN 25988 62604	IMDCOD 25975 62567	IMDCOD 25975 62567
HE 25983 62577	HH 25982 62576	IALT 25977 62571	IDEL 25976 62570	INDR 25903 62457
INDLAS 25965 62555	INOPRI 25954 62542	INDP 25955 62543	INDPS 25953 62541	INDR 25903 62457
INOSTP 25902 62456	INOSTR 25901 62455	INDUTP 25900 62454	IPRINT 23213 55255	JBYCTR 23211 55253
JINPUT 25890 62442	JS 25889 62441	KS 25888 62440	LP2 25886 62436	L 25887 62437
NCOUNT 23212 55254	NPSI 25895 62435	NSR 25883 62433	NS 25884 62434	OGIVEH 25882 62432
OGIVEK 25881 62431	PE 25872 62420	PRALIN 25810 62322	PRAL 25870 62416	PRATIN 25749 62225
PRAT 25809 62321	PRADIRA 25748 62224	PROS 25688 62130	PAP 25687 62127	PR 25871 62417
PRSAVE 25686 62126	P 25880 62430	PSCALC 25285 61305	PSI 25225 61211	PSITCU 25165 61115
PS 25685 62125	QM 25164 61114	RESTAR 25162 61112	RETHET 23219 55263	REN 23217 55261
REX 23218 55262	RHO12 25040 60720	RHOALC 25101 61015	RHOE 25041 60721	RHO 23161 61111
RHOSTG 25039 60717	RN 25038 60716	RNS 25037 60715	R 25163 61113	RSC 24986 60632
RS 24985 60631	RS 24986 60633	SCHLIN 24984 60630	SCHTIN 24983 60627	SCL 24982 60626
SCI 24922 60532	SHANGL 24862 60436	SIGMAC 24861 60435	SIGMAH 24801 60341	SIGMAU 24741 60245
STADIS 24681 60151	TAUM 24620 60054	TAUP 24560 57760	TESTRA 24500 57664	THETAT 24499 57663
THPER 24498 57662	TIN 24497 57661	TITLE1 24496 57660	TITLE2 24484 57644	TITLE3 24472 57630
TH 24460 57614	T 24680 60150	TVM2 24400 57520	TVPNO 24398 57516	TVNO 24399 57517
TV02 24397 57515	U12 24336 57420	UM2 24152 57130	UE 24275 57323	UINF 24274 57322
ULOLIM 24273 57321	UM1 24212 57224	X1 23431 55607	UM 24272 57320	U 24396 57514
US 24092 57034	WDOT 24032 56740	X 23432 55610	XL 23430 55606	YALS 23429 55605
XRH 23379 55523	YTHC 23255 55327	YTH 23256 55310	XU12 23377 55521	YCALC 23316 55424
Z1 23242 55312	Z1 23244 55314	Z1S 23232 55300	YTHU 23245 55315	Z1L 23243 55313
Z2S 23220 55264	Z1 23242 55312	Z1S 23232 55300	Z2R 23230 55276	Z2 23231 55277

SUBROUTINE UEDGE(J)

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT
1) 78 00116	2) 69 00105	3) 71 00107	4) 72 00110	DEC	OCT

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
20	12	00026	30	15	00034	40	16	00036
200	21	00061				50	17	00043
						100	18	00045

SUBROUTINE VISLAT

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COMMON AIL,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,AB1T,AB2T,
1AB3T,AB4T,AB5T,AB6T,AB7T,AC12,AH12,ALPHA,ASR,AU12,B1T,B2T,B3T,
2B4T,B5T,B6T,B7T,B8T,B8B1T,B8B2T,B8B3T,B8B4T,B8B5T,B8B6T,B8B7T,B8B12,BH12,
32B38LOCK,BSR,BU12,C,C12,C6C,CCALC,CE,CM,CM1,CM2,CONEAN,CP,CPE,CS,
44CSR,DCOPI2,DEL,DELTAP,DELTAX,DELXOD,DELXST,DHOP12,DIST,OKOL,
5DOKOT,DN2,DN2D02,DNG,D002,DSCRIP,DUDP12,EDCNS,EPSI,
66EPSIC,EPSIT,EPSIU,ETA,FA,FB,FC,FEDA,FEDB,
77FEDC,FH,FH12,FHCALC,FHE,FHM,FH2,FHS
COMMON FINO,FK,FKPSI,FL,FLE1IN,FLE1IN,FLEW1,FLEW1,
1IFL22,FLND,FLNDOP,FLQ22,FH,FMUL,FMUL12,FNUTIM,FNUTIP,FNDSSM,
2FNR22FNOSL,FSH,FSH2,FSH12,FSPH,FSK,FSKRA,FSKRB,FSRRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSNE,FSMN,FSMNO,FSMNOP,FSMO,GAMM,HE,
44H12,IAT,IOEL,INOCOD,INOLAS,INDOP,INDOP1,INDPS,INDR,
5INDSTP,INDSTR,INDTYP,INPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6OGVIEH,OGVIEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PRDS,PRP,PRSAVE,PS,PSALC,PSI,PSITCU,QM,PR,RESTAR,RHO,
1IRHOCAL,RHDE,RHOL2,RHDSIG,RN,RNS,RS,RSC,RSM,SCHLIN,SCMTIN,
22SCL,SCT,SHANGL,SIGMAH,SIGMAU,
3STADIS,T,TAUM,TAUP,TESTRA,THEAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TM,TVN2,
5TVNO,TVNOP,TVO2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UW1,
6UM2,US,WOOT,X,X1,XL,XLS,XRN,X5,XUL2,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REM,FNUREX,FNUREW,CSUB,I,PRINT,NCOUNT,JBYCTR
1,F,SH12,T12,Y12,STRLL,STRLL,STRAU,RHOU12,AAU

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```

DIMENSION AC12(10),ASR1(0),BIT(60),B2I(60),B3T(60),B4I(60),B5T(60),
1,B6T(60),B7T(60),BCL2(10),BLCKM(60),BSR(10),C(60),C12(10),
2CC15,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CST(60,10),CSR(10),DCOPL2(10),DKDL(60,10),DKDT(60,10),
4EDENS(60),FHI(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPST(60),FLEWL(60),FLENT(60),FLN2(60),FLND(60),
6FLNPO(60),FLOZ(60),FMI(10),FMUL(60),FMUTIM(60)
DIMENSION FMUTIP(60),FSM(60),FSHI(60,10),FSH12(10),FSKRA(10),
1FSKRBL(10),FSKRC(10),FSKRP(10),HK(5),IMDCOO(10),
2INOLAS(10),INDPS(50),INDTP(10),P(8),PRDIRA(60),
3PRAL(60),PRAT(60),PS(B,50),PSCALC(60),PSI(60),RMD(60),
4RHOCAL(60),RNS(50),SCLT(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITL1(12),TITL2(12),TITL3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(60),UML(60),UM2(60),US(60),
1MOOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),ZIR(10),
2Z2R(10)

```

00 100 N=1,LP2
100 FMUL(N)=3.04566E-8*TM(N)+1.5/(110.333+TM(N))
REVER=RHO(L)*U(L)*NS
00 600 N=2,LP2

```

160 DEL12=SQRIF(DELTA1)
AAU=(2.0+RH0(2)*U(2)-RH0(3)*U(3))/DEL12+.58579
BBU=(RH0(2)*U(3)-1.*14.*RH0(2)*U(2))/DELTA/.58579
Y12=(2.0/BBU/RS*LOGF1.0+BBU/AAU*DEL12)
Y12=2.0/BBU/RS*LOGF(1.0+BBU/AAU*SQRIF(.5*DELTA1))

```

```

RHO12=AAUDEL12+.7071+BBU+.5*DELTA
RURNM=RHO(1)*U12+RS
RURN1=RHO(2)*U12+RS
RURN=RHO(2)*U(2)+RS
RURNP=RHO(3)*U(3)+RS
Y2K2P=Y(2)*DELTA*(-.375/RURN+.125+RURNP)
Y2K2M=Y(2)-DELTA*(-.125/RURNM+.375/RURN)
P2K2P=PSI(2)+.5*DELTA
P2K2M=PSI(2)-.5*DELTA
FMUT1M(2)= RHO12*U12+RS+RHO12 *ABS(F(OUOPI2)
GO TO 270
269 Y(N)=Y(N-1)+.5*DELTA/RS*(1.0/(RHO(N)*U(N))+1.0/(RHO(N-1)*U(N-1)))
RURNM=RHO(N-1)*U(N-1)+RS
RURN=RHO(N)*U(N)+RS
RURNP=RHO(N+1)*U(N+1)+RS
Y2K2P=Y(N)*DELTA*(-.375/RURN+.125/RURNP)
Y2K2M=Y(N)-DELTA*(-.125/RURNM+.375/RURN)
P2K2P=PSI(N)+.5*DELTA
P2K2M=PSI(N)-.5*DELTA
FMUT1M(N)= (RHO(N)+RHO(N-1))* (RURN+RURNM)*ABS(F(U(N)-U(N-1)))/
DELTA+.25
270 FMUT1P(N)=(RHO(N+1)+RHO(N))* (RURNP+RURN)*ABS(F(U(N+1)-U(N)))/DELTA+.
1.25
1*2 FLTP=(Y(L))*(.14-.08*(1.0-Y2K2P/Y(L)))*2-.06*(1.0-Y2K2P/Y(L))*4))*
1*2 FLTM=(Y(L))*(.14-.08*(1.0-Y2K2M/Y(L)))*2-.06*(1.0-Y2K2M/Y(L))*4))*
1*2 PLTP=(PSI(L)/REUER+.14-.08*(1.0-P2K2P/PSI(L)))*2-.06*(1.0-P2K2P/P
SI(L))*4))*2
PLTM=(PSI(L)/REUER+.14-.08*(1.0-P2K2M/PSI(L)))*2-.06*(1.0-P2K2M/P
SI(L))*4))*2
FMUT2P=-.25*(RHO(N+1)+RHO(N))* (FKPSI(N+1)+FKPSI(N))*Y(L)*U(L)
FMUT2M=-.25*(RHO(N)+RHO(N-1))* (FKPSI(N)+FKPSI(N-1))*Y(L)*U(L)
FMUT6P=FMUT2P/Y(L)*PSI(L)/REUER
FMUT6M=FMUT2M/Y(L)*PSI(L)/REUER
FMUT1P(N)=BIT(N+1)* (Y2K2P+PK)*2+FMUT1P(N)+B2T(N+1)*FMUT2P+B3T(N+1)
1)*.5*(FMUL(N)+FMUL(N+1))*B4T(N+1)*FLTP+FMUT1P(N)
2+B5T(N+1)* (P2K2P+FK/REUER)*2+FMUT1P(N)+B6T(N+1)*FMUT6P+B7T(N+1)*
3PLTP+FMUT1P(N)
600 FMUT1M(N)=BIT(N)* (Y2K2M+PK)*2+FMUT1M(N)+B2T(N)*FMUT2M+B3T(N)*.5*(
1FMUL(N)+FMUL(N-1))*B4T(N)*FLTM+FMUT1M(N)
2+B5T(N)* (P2K2M+FK/REUER)*2+FMUT1M(N)+B6T(N)*FMUT6M+B7T(N)*PLTM*
3FMUT1M(N)
IF(SENSE SWITCH 2)*650,700
650 WRITE OUTPUT TAPE 6,655,AU12,XU12
655 FORMAT(10X$HAU12=1PE13.5,5HXU12=1PE13.5)
700 RETURN
END(1,1,C,0,0,0,0,1,0,0,0,0,0,0,0)

```

SUBROUTINE VISLAT

DEC OCT
633 01171

DEC OCT
ALL 32561 77461
A4L 32556 77454
AB1T 32552 77450
AB6T 32547 77443
ASR 32533 77425
B4T 32342 77126
887T 32101 76545
887T 32096 76540
8012 32014 76416
CM1 30143 72677
CP 29532 71534
DCDP12 28920 70370
DELXST 28906 70352
DN2D02 27702 66066
DUOP12 27698 66062
EPSIT 27634 65762
FC 27629 65755
FHCLC 27564 65654
FHS 27383 65367
FLETIN 27259 65173
FLNO 27078 64706
FMUL 26888 64410
FNUREW 23215 55257
FSH1 26644 64024
FSKRD 26012 62634
FSK 26033 62661
FSMU 25985 62601
IDEL 25976 62570
INDPS 25953 62541
IPRINT 23213 55255
LP2 25886 62436
NS 25884 62434
PRAL 25870 62416
PRP 25687 62127
PSI 25225 61211
RETHET 23219 55263
RHOE 25041 60721
RNS 25037 60715
SCHLIN 24984 60630
SIGMAC 24861 60435
STRUL 23205 55246
THETAT 24499 57663
TITLE3 24472 57650
TVNO 24399 57517
UINF 24274 57322
U 24396 57514
XLS 23429 55605
Y12 23208 55250

STORAGE NOT USED BY PROGRAM

DEC OCT
23203 55243

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC OCT
A1T 32560 77460
A4T 32555 77453
AB2T 32551 77447
AB7T 32546 77442
AU12 32523 77413
B5T 32282 77032
883T 32100 76544
8C12 32095 76537
C12 31413 75265
CM2 30133 72665
C 32013 76415
DEL 28910 70356
DHDP12 28905 70351
DN2 27703 66067
EDEM5 27697 66061
EPSIU 27633 65761
FEDA 27628 65754
FME 27504 65560
FINO 27323 65273
FLEWL 27258 65172
FLO2 26958 64516
FMUTIM 26827 64313
FNUREX 23216 55260
FSMP 26034 62662
FSKRD 26002 62622
FSME 25989 62605
GAMH 25984 62600
INDCOO 25975 62567
INDR 25903 62457
JBYCTR 23211 55253
L 25887 62437
OGIVEN 25882 62432
PRATIN 25749 62225
PR 25071 62417
PSITCU 25165 61115
REN 23217 55261
RHO 25161 61111
R 25163 61113
SKLTIN 24983 60627
SIGMAH 24801 60341
THPER 24498 57662
T12 23209 55251
TM 24460 57614
TV02 24397 57515
ULOLIM 24273 57321
US 24092 57034
XRM 23379 55523
YCAL 23316 55424

DEC OCT
A2 32559 77457
A5L 32554 77452
AB3T 32550 77446
AC12 32545 77441
81T 32522 77412
B5T 32222 76736
884T 32099 76543
BM12 32085 76525
CCALC 31353 75171
CM 30743 74027
CSR 28930 70402
DELTA 28909 70355
DIST 28904 70350
DN2 27701 66065
EPSIC 27636 65764
ETA 27632 65760
FEOR 27627 65753
FHM2 27443 65463
FKPSI 27321 65271
FLENT 27198 65076
FL 27261 65175
FMUTIP 26767 64217
FSH12 23210 55252
FSH 26705 64121
FSKRD 26001 62621
FSMNO 25986 62602
HC 25983 62577
INDLAS 25965 62553
JIMPUT 25890 62442
NCOUNT 23212 55254
UGIVEK 25881 62431
PRAT 25809 62321
PRSAVE 25686 62126
PS 25685 62125
REX 23218 55262
RHO2TG 25039 60717
RSC 24966 60632
SCI 24502 60626
SIGMAU 24741 60245
TAUM 24620 60054
TIN 24497 57661
T 24680 60150
U12 24336 57420
UM1 24212 57224
WDOT 24032 56740
X 23432 55610
Y 23376 55520

DEC OCT
A3L 32558 77456
A5T 32553 77451
AB4T 32549 77445
AH12 32535 77427
B2T 32462 77316
87T 32162 76642
885T 32098 76542
BLOCK 32084 75524
CC 31403 75253
CONEAN 29533 71535
CS 29530 71532
DELTA 28908 70354
DKDL 28903 70347
DO2 27700 66064
EPSIM 27635 65763
FA 27631 65757
FEDC 27626 65752
FHM 27503 65557
FK 27322 65272
FLN2 27138 65002
FM 26898 64422
FNDSSH 26707 64123
FSHE 26645 64025
FSKRA 26032 62660
FSKRD 26000 62620
FSMNO 25987 62603
HM 25982 62576
INDPRI 25954 62542
INDSTR 25901 62455
JS 25889 62441
NPSI 25885 62435
PE 25872 62420
PROIRA 25748 62224
P 25880 62430
GM 25164 61114
RHO12 25040 60720
RHO12 23205 55245
RSM 24985 60631
SCT 24922 60532
STADIS 24681 60151
TAUP 24560 57760
TITLE1 24496 57660
TVN2 24400 57520
UCALC 24335 57417
UM2 24152 57130
XI 23431 55607
YTHC 23255 55327

DEC OCT
A33 32557 77455
AAU 32304 55244
AB5T 32548 77444
ALPHA 32534 77426
83T 32402 77222
881T 32102 76546
886T 32097 76541
BSR 32024 76430
CE 30753 74041
CPE 29531 71533
CSUB 23214 55256
DELXOD 28907 70353
DKDT 28303 67217
OSCRIP 27699 66063
EPSI 27637 65765
FB 27630 65756
FH12 27565 65655
FH 27625 65751
FLELIN 27260 65174
FLNOP 27018 64612
FMUL12 26828 64314
FNDSSL 26706 64122
FSH112 26044 62674
FSKRB 26022 62648
FSKRD 25999 62617
FSM 25988 62604
IAT 25977 62571
INDP 25925 62543
INDTYP 25900 62454
KS 25888 62440
NSK 25883 62433
PRALIN 25810 62322
PRDS 25688 62130
PSCALC 25285 61305
RESTAR 25162 61112
RHOAL 25101 61015
RN 25038 60716
RS 24987 60633
SHANGL 24862 60436
STRL 23207 55247
FESTRA 24500 57664
TITLE2 24484 57644
TVNOP 24398 57516
UE 24275 57323
UM 24272 57320
XL 23430 55606
XU12 23377 55521
YIN 23256 55330

SUBROUTINE VISLAT

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YTHU 23245 55315 Z1L 23243 55313 Z1R 23242 55312 Z1 23244 55314 Z1S 23232 55300
Z2R 23230 55276 Z2 23231 55277 Z2S 23220 55264

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
BRU	632 01170	DEL12	631 01167	FLTM	630 01166	FLTP	629 01165	FMUT2M	628 01164
FMUT2P	627 01163	FMUT6M	626 01162	FMUT6P	625 01161	N	624 01160	P2K2M	623 01157
P2K2P	622 01156	PLTM	621 01155	PLTP	620 01154	REUR	619 01153	RURN1	618 01152
RURNM	617 01151	RURNP	616 01150	RURN	615 01147	Y2K2M	614 01146	Y2K2P	613 01145

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC
8)KF	655 01131				

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT
1)	602 01132	2)	571 01073	3)	575 01077
E18	554 01052			6)	590 01116
				C)GI	612 01144

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT
EXP(3	0 00000	LOG	2 00002	SQRT	1 00001
				(FIL)	4 00004
				(ISTH)	3 00003

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP(3	LOG	SQRT	(FIL)	(ISTH)
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EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC
100	12 00022	160	16 00055	180	22 00157
600	51 00761	650	53 01053	700	55 01067
				269	32 00261
				270	41 00406

V9 M1 1-18-61

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SUBROUTINE WDDTRT(NSTART,NEND)

SUBROUTINE WDDTRT(NSTART,NEND)

```

COMMON A1L,A1T,A2,A3L,A3T,A4L,A4T,A5L,A5T,A81T,A82T,
1AB3T,A84T,A85T,A86T,A87T,AC12,AH12,ALPHA,ASR,AUIP,81T,82T,83T,
284T,85T,86T,87T,88T,883T,884T,885T,886T,887T,888T,889T,890T,
3BLOC,BSR,BUI2,C,C12,CC,CCALC,CE,CM,CM2,CDNEAN,CP,CPE,CS,
4CSR,DCDP12,DEL,DELTAP,DELXDD,DELXST,OHDP12,DIST,OKDL,
5OKDT,DN2,DN2DD2,DNC,DD2,DSCRIPT,DUDP12,EDENS,EPS1,
6EPSIC,EPSIH,EPSIT,EPSIU,ETA,FA,F8,FC,FEDA,FED8,
7FEDC,FI,FI12,FHCALC,FHE,FHM,FHM2,FHS
COMMON FINO,FK,FKPSI,FL,FLELIN,FLENT,FLEWL,FLEWT,
1FLN2,FLND,FLNDP,FLC2,FM,FMUL,FMUL12,FMUTIM,FMUTIP,FNDSSH,
2FNDSSL,FSH,FSHE,FSHI,FSHI12,FSHP,FSK,FSKRA,FSKRB,FSKRC,FSKRD,
3FSKRE,FSKRF,FSKRK,FSME,FSMN,FSMND,FSMNP,FSMD,GAMM,HE,
4HH,IALT,IDEL,INDCDC,INCLAS,INDP,INOPRI,INDPS,INDR,
5INDSTP,INDSTR,INCTYP,INPUT,JS,KS,L,LP2,NPSI,NS,NSR,
6DGIVEH,DGIVEK,P,PE,PR,PRAL,PRALIN,PRAT,PRATIN,PROIRA
COMMON PROS,PRP,PRSAVE,PS,PSCALC,PSI,PSITCU,QM,R,RESTAR,RHO,
1RHDCAL,RHDE,RHDI2,RHDSIG,RN,RNS,RS,RSC,RSM,SCHLIN,SCHTIN,
2SCL,SCT,SHANGL,SIGMAC,SIGMAH,SIGMAU,
3STADIS,T,TAUM,TAUP,TESTRA,THETAT,THPER,TIN,
4TITLE1,TITLE2,TITLE3,TP,TVN2,
5TVND,TVNDP,TVD2,U,U12,UCALC,UE,UINF,ULOLIM,UM,UM1,
6UM2,US,WDOT,X,XI,XL,XLS,XRN,XS,XU12,Y,YCALC,YTH,YTHC,
7YTHU,Z1,Z1L,Z1R,Z1S,Z2,Z2R,Z2S
COMMON RETHET,REX,REW,FNUREX,FNUREW,CSUB,IPRINT,NCOUNT,JBYCTR
1,FSHI2,Y12,Y12L,STRLL,STRUL,RHOU12,AAU,EHP,FSK15,
2FSMD15,FSMN15,FSME5

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DIMENSION AC12(10),ASR(10),81T(60),82T(60),83T(60),34T(60),85T(60)
1,86T(60),87T(60),88T(60),883T(60),884T(60),885T(60),886T(60),887T(60),888T(60),889T(60),890T(60),
2CC(5,10),CCALC(60,10),CE(10),CM(60,10),CM1(10),
3CM2(60,10),CS(60,10),CSR(10),DCDP12(10),DKOL(60,10),DKCT(60,10),
4EDENS(60),FH(60),FHCALC(60),FHM(60),FHM2(60),FHS(60),
5FKPSI(60),FLEWL(60),FLEWT(60),FLN2(60),FLND(60),
6FLNDP(60),FLD2(60),FM(10),FMUL(60),FMUTIM(60)
DIMENSION FMUTIP(60),FSH(60),FSHI(60,10),FSHI12(10),FSKRA(10),
1FSKRB(10),FSKRC(10),FSKRK(10),HH(5),INDCOO(10),
2INDLAS(10),INDPS(50),INDTYP(10),P(8),PRDIRA(60),
3PRAL(60),PRAT(60),PS(8,50),PSCALC(60),PSI(60),RHD(60),
4RHOCAL(60),RNS(50),SCL(60),SCT(60),SIGMAC(60),
5SIGMAH(60),SIGMAU(60),T(60),TAUM(60),TAUP(60),
6TITLE1(12),TITLE2(12),TITLE3(12),TM(60),U(60)
DIMENSION UCALC(60),UM(50),UM1(60),UM2(60),US(60),
1WDOT(60,10),XLS(50),Y(60),YCALC(60),YTHC(10),Z1R(10),
2Z2R(10)

```

10 NSTART=NSTART

NEND=NEND

DD 300 N=NSTART,NEND

ETT228=5.0+3.0*EXP(-228.0/T(N))+EXP(-327.0/T(N))

ETT178=1.0+EXP(-178.0/T(N))

ETT2274=1.0-EXP(-2274.0/T(N))

ETT2740=1.0-EXP(-2740.0/T(N))

ETT3395=1.0-EXP(-3395.0/T(N))

ETT1130=3.0+2.0*EXP(-1130.0/T(N))

PAGE 2

SUBROUTINE WOORT (NSTART, NENO)

```

      RH000=FM(2)*11.584906/T(N)*ET2274*ETT228**2/ET1130*FSM015
      1*FSK15*3.87871E-11*T(N)**1.5/EHP
      RH00N=FM(4)*257.8804/T(N)*ET3395*FSMN15*FSK15
      1*3.87871E-11*T(N)**1.5/EHP
      RH00NO=FM(2)*77.267586*(FM(4)/FM(5))**2.5/T(N)*ET2740*ETT2
      128/ET178*FSM015*FSK15*3.87871E-11*T(N)**1.5/EHP
      RHODE=FM(7)*13.346219*ET2740/ET3395/ET178*FSMES
      1*FSK15*3.87871E-11*T(N)**1.5/EHP*FSME
      SIGMA=(FM(1)*FM(4)/FM(5)/FM(2))**2.5*.1790*ET2740/ET2274*ET1130/E
      1TT228/ET178
      GAMMA=(FM(5)*FM(4)/FM(3)/FM(2))**2.5*18.88*ET3395/ET2740*ET178/ET
      1228
      FKBAR=( FM(6)*FM(7) /FM(4)/FM(2))**2.5*T(N)/5.789/ET3395/ETT228
      TT2=1.0/SQRT(T(N))
      T32=TT2*TT2*TT2
      FSKRA(1)=2.2E-7*T32
      FSKRA(2)=6.2E-7*T32
      FSKRA(3)=1.7E-11*TT2
      FSKRA(4)=8.3E-12*TT2
      FSKRA(5)=FSKRA(4)
      FSKRA(6)=FSKRA(4)
      FSKRA(7)=FSKRA(4)
      FSKRB(1)=3.0E-11*TT2
      FSKRB(2)=FSKRB(1)
      FSKRB(3)=7.6E-11*TT2
      FSKRB(4)=6.5E-6*T32
      FSKRB(5)=FSKRB(1)
      FSKRB(6)=FSKRB(1)
      FSKRB(7)=FSKRB(1)
      FSKRC(1)=2.8E-7*T32
      FSKRC(2)=FSKRC(1)
      FSKRC(3)=FSKRC(1)
      FSKRC(4)=FSKRC(1)
      FSKRC(5)=5.5E-6*T32
      FSKRC(6)=FSKRC(1)
      FSKRC(7)=FSKRC(1)
      FSKRO=2.2E-14*TM(N)*EXP(-3560./TM(N))
      FSKRF=3.0E-3*T32
      FSKRK(1)=FSKRA(1)
      FSKRK(2)=FSKRA(1)
      FSKRK(3)=FSKRA(1)
      FSKRK(4)=FSKRA(1)
      FSKRK(5)=FSKRA(1)
      FSKRK(6)=FSKRA(1)
      FSKRK(7)=FSKRA(1)
      FSKT=FSK*T(N)*.846389E19
      EMD02=EXP(-002/FSKT)
      EMD0N2=EXP(-DN2/FSKT)
      EMD0NO=EXP(-ONO/FSKT)
      EMDINO=EXP(-FINO/FSKT)
      SUMCM=0.0
      SUMCMA=0.0
      SUMCMB=0.0
      SUMCMC=0.0
      SUMCMK=0.0
      00 150 1=1.NS

```

SUBROUTINE WDDTRT(NSTART,NEND)

```

SUMCM=SUMCM+C(N,1)/FM(1)
SUMCPA=SUMCPA+C(N,1)/FM(1)+FSKRB(1)
SUMCMB=SUMCMB+C(N,1)/FM(1)+FSKR8(1)
SUMCMC=SUMCMC+C(N,1)/FM(1)+FSKRC(1)
SUMCMK=SUMCMK+C(N,1)/FM(1)+FSKRK(1)
150 A=2.0*FL/FM(2)*C(N,1)+1.94008E25*EMD2-RHD(N)
1.1.94008E25*(N,2)*C(2)+4.9778
8=2.0*FL/FM(4)*SUMCMB+RHD(N)*(RHDON+C(N,3)*1.94008E25*EMN2-RHD(N)
1.1.94008E25*(N,4)*C(2)+4.9778
G=FL*FM(5)/FM(4)/FM(2)+SUMCMC+RHD(N)*(RHDND+C(N,5)*1.94008E25*EMD
1ND-RHD(N)+1.94008E25*(N,4)*C(N,2)+4.9778
0=FL*FM(5)/FM(4)/FM(1)+FSKRDRHD(N)*(SIGMA+C(N,5)*C(N,2)*1.94008E2
15*EMOND/EMD2-C(N,1)+1.94008E25*(N,4)*1.6018E-2
E=FL*FSKRE/FM(4)*RHD(N)*(GAMMA+C(N,3)*1.94008E25*(N,2)*EMDN2/EPON
1D-C(N,5)+1.94008E25*(N,4)*1.6018E-2
F=FL*FSKRF/FM(7)*RHD(N)*(FK8AR+C(N,2)*1.94008E25*(N,4)*EMIND/EMDN
1D-C(N,6)+1.94008E25*(N,7)*1.6018E-2
TK=FL/FM(7)*SUMCMK+RHD(N)*(RHDDE+C(N,5)*1.94008E25*EMIND-RHD(N)*C(
1,N,6)+1.94008E25*(N,7)+4.9778
WDDT(N,2)=(A+FM(2)/FM(5))*(G-D-E)-FM(2)/FM(6)*F)*RHD(N)/FL
WDDT(N,4)=(B+FM(4)/FM(5))*(G+D+E)-FM(4)/FM(6)*F)*RHD(N)/FL
WDDT(N,1)=(A+FM(1)/FM(5))*O)*RHD(N)/FL
WDDT(N,3)=(B+FM(3)/FM(5))*E)*RHD(N)/FL
WDDT(N,5)=(G+O+E-TK)*RHD(N)/FL
WDDT(N,6)=(F+TK)*RHD(N)/FL
IF(SENSE SWITCH 3)250,300
250 WRITE OUTPUT TAPE 6,255,A,8,G,D,E,F,TK,SUMCM,SUMCPA,SUMCM8,SUMCMC,
1SUMCMK,EMD22,EMON2,EMDND,EMINO,FSKRA(1),FSKR8(1),FSKRC(1),FSKRE,FS
2KRF,FSKRB(1),RHDOD,RHDON,RHDND,RHDEE,SIGMA,GAMMA,FKBAR,ETA,E,T228
3,E1178,E1227,E12740,E13395,E1130,T(N),TM(N),T2,T32,FSKT
255 FORMAT(1H 7E10.3)
300 WDDT(N,7)=(F+TK)*RHD(N)/FL*FM(7)/FM(6)
RETURN
END(1,1,0,0,0,0,0,1,0,0,0,0,0,0,0,0)

```


SUBROUTINE WOOTR(INSTART,NENO)

Y12 23208 55250	YCALC 23316 55424	Y 23376 55520	YTHC 23255 55327	YTH 23256 55330
YTHU 23245 55315	Z1L 23243 55313	Z1R 23242 55312	Z1 23244 55314	Z1S 23232 55300
Z2R 23230 55276	Z2 23231 55277	Z2S 23220 55264		

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENT

	OEC	OCT	OEC	OCT	OEC	OCT	DEC	OCT	DEC	OCT	
A	857	01522	8	856	01530	0	855	01527	EMDN2	854	01526
EM002	852	01524	EMINO	851	01523	E	850	01522	ET1130	849	01521
ET2274	847	01517	ET2740	846	01516	ET3395	845	01515	ET1228	844	01514
F	842	01512	FSKT	841	01511	GAMMA	840	01510	G	839	01507
RHOONO	837	01505	RHOEN	836	01504	RHODO	835	01503	SIGMA	834	01502
SUMCM8	832	01500	SUMCMC	831	01477	SUMCMK	830	01476	SUMCM	829	01475
TK	827	01473	TT2	826	01472				T32	828	01474
									EMONO	853	01525
									ET178	848	01520
									FK8AR	843	01513
									RMODE	838	01505
									SUMCPA	833	01501

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

	EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
817V	255	01463						

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

	OEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1)	820	01464	2)	770	01402	3)	774	01406
						6)	812	01454
							CIG0	825 01471

LOCATIONS OF NAMES IN TRANSFER VECTOR

	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3	OEC	OCT	EXP(3</
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ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

EXP EXP(3 SORT (FIL) (STH)

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

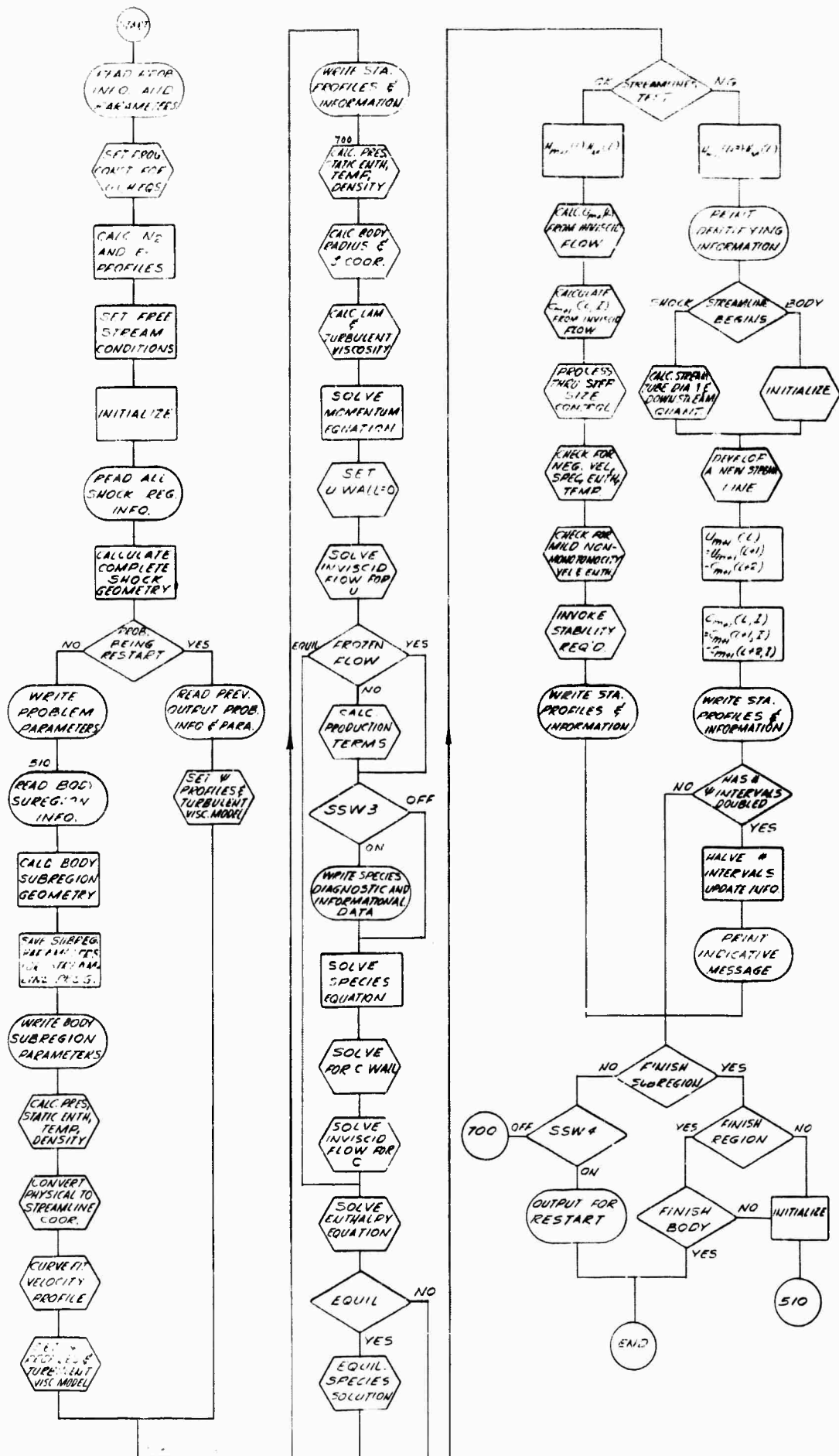
	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	
10	11	00030	150	74	00645	250	89	01230	91	01362

APPENDIX III

FLOW DIAGRAM

CHIEF CAVITY REACTING FLOW LAYER

OVERALL PROGRAM LOGIC



APPENDIX 4

SAMPLE INPUT

TITLE CARD
FIRING RANGE BLUNTED CONE

TITLE CARD
NON UNITY FLOW PARAMETERS

TITLE CARD
LAMINAR CHEMISTRY RUN

LP2	NS	NPSI	INDSTR	FNDSSL	FNDSSH	IALT
20	7	1	1	.5E-2	.75E-1	150
AIL	AIT	A2	A3L	A3T	A4L	A4T
1.0F0	0.0E0	1.0E0	1.0E0	0.0E0	1.0E0	0.0E0
ASL	AST	C(1,1)	C(2,1)	C(3,1)	C(4,1)	C(5,1)
1.0F0	0.0E0	.22741E0	.22170E0	.21183E0	.17982E0	.14297E0
C(6,1)	C(7,1)	C(8,1)	C(9,1)	C(10,1)	C(11,1)	C(12,1)
.11150E0	.85382E-1	.62616E-1	.43567E-1	.29410E-1	.20097E-1	.16908E-1
C(13,1)	C(14,1)	C(15,1)	C(16,1)	C(17,1)	C(18,1)	C(19,1)
.14904E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1	.14469E-1
C(20,1)	C(1,2)	C(2,2)	C(3,2)	C(4,2)	C(5,2)	C(6,2)
.14469E-1	.67227E-3	.33476E-2	.10007E-1	.36819E-1	.71043E-1	.10170E0
C(7,2)	C(8,2)	C(9,2)	C(10,2)	C(11,2)	C(12,2)	C(13,2)
.12798E0	.15152E0	.17185E0	.18753E0	.19831E0	.20215E0	.20462E0
C(14,2)	C(15,2)	C(16,2)	C(17,2)	C(18,2)	C(19,2)	C(20,2)
.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0	.20516E0
C(1,4)	C(2,4)	C(3,4)	C(4,4)	C(5,4)	C(6,4)	C(7,4)
.14702E-8	.30977E-7	.25366E-6	.34105E-5	.14424E-4	.35360E-4	.69228E-4
C(8,4)	C(9,4)	C(10,4)	C(11,4)	C(12,4)	C(13,4)	C(14,4)
.12614E-3	.22343E-3	.37977E-3	.60274E-3	.73494E-3	.84654E-3	.87483E-3
C(15,4)	C(16,4)	C(17,4)	C(18,4)	C(19,4)	C(20,4)	C(1,5)
.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.87483E-3	.73356E-2
C(2,5)	C(3,5)	C(4,5)	C(5,5)	C(6,5)	C(7,5)	C(8,5)
.13023E-1	.19050E-1	.28800E-1	.33728E-1	.35239E-1	.34955E-1	.33489E-1
C(9,5)	C(10,5)	C(11,5)	C(12,5)	C(13,5)	C(14,5)	C(15,5)
.31103E-1	.28245E-1	.25478E-1	.24262E-1	.23396E-1	.23195E-1	.23195E-1
C(16,5)	C(17,5)	C(18,5)	C(19,5)	C(20,5)	C(1,6)	C(2,6)
.23195E-1	.23195E-1	.23195E-1	.23195E-1	.23195E-1	.36175E-11	.93313E-10
C(3,6)	C(4,6)	C(5,6)	C(6,6)	C(7,6)	C(8,6)	C(9,6)
.87854E-9	.13790E-7	.61681E-7	.15267E-6	.29524E-6	.52305E-6	.88771E-6
C(10,6)	C(11,6)	C(12,6)	C(13,6)	C(14,6)	C(15,6)	C(16,6)
.14312E-5	.21502E-5	.25554E-5	.28882E-5	.29714E-5	.29714E-5	.29714E-5

C(17,6)	C(18,6)	C(19,6)	C(20,6)			
.29714E-5	.29714E-5	.29714E-5	.29714E-5			
RESTAR	DELTAX	EPSI	EPSIU	EPSIC	EPSIH	EPSIT
1.0E0	1.0E-9	1.0E0	0.5E-3	0.0E0	1.0E-4	1.0E-2
H(1)	H(2)	H(3)	H(4)	H(5)	H(6)	H(7)
.26496E8	.31276E8	.36058E8	.45620E8	.55182E8	.64744E8	.74306E8
H(8)	H(9)	H(10)	H(11)	H(12)	H(13)	H(14)
.83868E8	.93428E8	1.02985E8	1.12551E8	1.17333E8	1.21160E8	1.22112E8
H(15)	H(16)	H(17)	H(18)	H(19)	H(20)	FK
1.22113E8	1.22114E8	1.22115E8	1.22116E8	1.22116E8	1.22116E8	.4E0
CPE	FL	FSHE	GAMM	PE	RHOE	RHOSTG
.432F0	1.0E0	1.20096E2	1.4E0	3.0597E0	3.5642E-6	4.1379E-5
CE(1)	CE(2)	CE(3)	CE(4)	CE(5)	CE(6)	CE(7)
.232F0	0.0E0	.768E0	0.0E0	0.0E0	0.0E0	0.0E0
RN	UINF	ULOLIM	XS	ZIS	ZZS	ZIL
.05E0	15.2E3	100.0E0	.0519E0	.02806E0	.041305E0	1.5E0
U(1)	U(2)	U(3)	U(4)	U(5)	U(6)	U(7)
0.0F0	.42518E3	.85037E3	.17007E4	.25511E4	.34014E4	.42518E4
U(8)	U(9)	U(10)	U(11)	U(12)	U(13)	U(14)
.51022F4	.59525E4	.68029E4	.76533E4	.80785E4	.84186E4	.85037E4
U(15)	U(16)	U(17)	U(18)	U(19)	U(20)	
.85037E4	.85037E4	.85037E4	.85037E4	.85037E4	.85037E4	
FA	FB	FC	TESTRA	AB4T	AB2T	AB3T
0.4F0	0.0E0	0.0E0	2.0E-1	0.0E0	0.0E0	0.0E0
AB4T	AB5T	AB6T	AB7T	BB1T	BB2T	BB3T
0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0	0.0E0
BB4T	BB5T	BB6T	BB7T	FLELIN	FLETIN	PRALIN
0.0E0	0.0E0	0.0E0	0.0E0	1.4E0	1.4E0	.7E0
PRATIN	SCHLIN	SCHTIN	Y(1)	Y(2)	Y(3)	Y(4)
.7F0	.5E0	.5E0	0.0E0	.62716E-4	.11128E-3	.24304E-3
Y(5)	Y(6)	Y(7)	Y(8)	Y(9)	Y(10)	Y(11)
.39216E-3	.55812E-3	.74335E-3	.95388E-3	.12015E-2	.15123E-2	.19643E-2
Y(12)	Y(13)	Y(14)	Y(15)	Y(16)	Y(17)	Y(18)
.23168E-2	.24369E-2	.25270E-2	.26171E-2	.27072E-2	.27973E-2	.28874E-2
Y(19)	Y(20)					
.29775E-2	.30673E-2					
INDPRI	NSR	JINPUT	THPER			
5	4	20	.99E0			

ASR(1)	BSR(1)	CSR(1)	ZIR(1)	Z2R(1)	TYP	COO	LAS	IND	IND	IND
0.0E0	5.3775E0	0.0E0	1.036E-3	1.3880E-2	6	1	0			
								IND	IND	IND
ASR(2)	BSR(2)	CSR(2)	ZIR(2)	Z2R(2)	TYP	COO	LAS			
.60962E-3	13.067	.81680E-2	.042663E0	.064899E0	6	1	0			
								IND	IND	IND
ASR(3)	BSR(3)	CSR(3)	ZIR(3)	Z2R(3)	TYP	COO	LAS			
9.6118E-3	1.6625E1	.020312E0	.390380E0	.168759E0	6	1	0			
								IND	IND	IND
ASR(4)	BSR(4)	CSR(4)	ZIR(4)	Z2R(4)	TYP	COO	LAS			
.2026F0	.0896068E0	0E0	1.5E0	1.50E0	2	1	1			
INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7				
2	1	0	0	0	0	0				
OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)				
.0534E0	0.0E0	0.0E0	593.330E0	-410.15E0	0.0E0	0.0E0				
P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)				
0.0F0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0				
CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)				
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0				
CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)				
0.0E0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0				
CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)				
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0				
CC(1,6)	CC(2,6)	CC(3,6)	CC(4,6)	CC(5,6)	HH1	HH2				
36175E-11	0.0E0	0.0E0	0.0E0	0.0E0	.26496E8	0.0E0				
HH3	HH4	HH5	RN	XL	CONEAN					
0.0F0	0.0E0	0.0E0	.05E0	.06175E0	0.0E0					
INDP	INDR	INDLR	INDLSR	INDS5	INDS6	INDS7				
2	1	0	1	0	0	0				
OGIVEH	OGIVEK	P(1)	P(2)	P(3)	P(4)	P(5)				
.0534E0	0.0E0	0.0E0	213.56E0	-102.64E0	0.0E0	0.0E0				
P(6)	P(7)	P(8)	CC(1,1)	CC(2,1)	CC(3,1)	CC(4,1)				
0.0E0	0.0E0	0.0E0	.22741E0	0.0E0	0.0E0	0.0E0				
CC(5,1)	CC(1,2)	CC(2,2)	CC(3,2)	CC(4,2)	CC(5,2)	CC(1,3)				
0.0E0	.67227E-3	0.0E0	0.0E0	0.0E0	0.0E0	.76457E0				
CC(2,3)	CC(3,3)	CC(4,3)	CC(5,3)	CC(1,4)	CC(2,4)	CC(3,4)				
0.0F0	0.0E0	0.0E0	0.0E0	.14702E-8	0.0E0	0.0E0				
CC(4,4)	CC(5,4)	CC(1,5)	CC(2,5)	CC(3,5)	CC(4,5)	CC(5,5)				
0.0E0	0.0E0	.73356E-2	0.0E0	0.0E0	0.0E0	0.0E0				

CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .0717E0	CONEAN 0E0	
INDP 2	INDR 2	INDLR 0	INDLSR 0	INDSS 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 213.56E0	P(3) -102.64E0	P(4) 0E0	P(5) 0E0
P(6) 0E0	P(7) 0E0	P(8) 0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0

CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .0864E0	CONEAN .13671E0	
INDP 2	INDR 2	INDLR 0	INDLSR 0	INDSS 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 43.840E0	P(3) -4.4213E0	P(4) 0.0E0	P(5) 0.0E0
P(6) 0.0E0	P(7) 0.0E0	P(8) 0.0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0
CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL .2877E0	CONEAN .136718E0	

INOP 2	INDR 2	INDLR 1	INDLSR 1	INDS5 0	INDS6 0	INDS7 0
OGIVEH 0.0E0	OGIVEK 0.0E0	P(1) 0.0E0	P(2) 19.228E0	P(3) -.13784E0	P(4) 0.0E0	P(5) 0.0E0
P(6) 0.0E0	P(7) 0.0E0	P(8) 0.0E0	CC(1,1) .22741E0	CC(2,1) 0.0E0	CC(3,1) 0.0E0	CC(4,1) 0.0E0
CC(5,1) 0.0E0	CC(1,2) .67227E-3	CC(2,2) 0.0E0	CC(3,2) 0.0E0	CC(4,2) 0.0E0	CC(5,2) 0.0E0	CC(1,3) .76457E0
CC(2,3) 0.0E0	CC(3,3) 0.0E0	CC(4,3) 0.0E0	CC(5,3) 0.0E0	CC(1,4) .14702E-8	CC(2,4) 0.0E0	CC(3,4) 0.0E0
CC(4,4) 0.0E0	CC(5,4) 0.0E0	CC(1,5) .73356E-2	CC(2,5) 0.0E0	CC(3,5) 0.0E0	CC(4,5) 0.0E0	CC(5,5) 0.0E0
CC(1,6) 36175E-11	CC(2,6) 0.0E0	CC(3,6) 0.0E0	CC(4,6) 0.0E0	CC(5,6) 0.0E0	HH1 .26496E8	HH2 0.0E0
HH3 0.0E0	HH4 0.0E0	HH5 0.0E0	RN .05E0	XL 1.5415E0	CONEAN .136718E0	

Appendix V

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APPENDIX V

SAMPLE OUTPUT

GENERAL APPLIED SCIENCE LABS

FINITE DIFFERENCE SOLUTION OF CHEMICALLY REACTING AIR BOUNDARY LAYERS

FIRING RANGE BLUNTED CONE

NON UNITY FLOW PARAMETERS

LAMINAR CHEMISTRY RUN

FLIGHT CONDITIONS AND FREE STREAM PROPERTIES

ALT (K FT)	CP (FT/SEC) SQ/K	STAT ENTH (FT/SEC) SQ	GAMMA	PRESS (LB/SC FT)	DENSITY (SLUGS/CU FT)	TEMP (DEG K)	VEL (FT/SEC)
150	4.3200E-01	1.2009E 02	1.4000E 00	3.05970E 00	3.56420E-06	2.78000E 02	1.52000E 04
C(O2)	C(O)	C(N2)	C(N)	C(NO)	C(NO+)	C(E-)	
2.32000E-01	0.	7.68000E-01	0.	0.	0.	0.	

SHOCK CONDITIONS

STAG DENSITY
(SLUGS/CU FT)
4.13790E-05

NSR

4

SHOCK REGION NO 1

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	0.	5.37750E 00	0.	1.03600E-03 1.38801E-02

SHOCK REGION NO 2

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	6.09620E-04	1.30670E 01	8.16800E-03	4.26630E-02 6.49117E-02

SHOCK REGION NO 3

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)
PARABOLIC	0.	0.	9.61180E-03	1.66250E 01	2.03120E-02	3.90300E-01 1.68758E-01

SHOCK REGION NO 4

TYPE	SHANGL (RAO)	STANDOFF OIST (FT)	ASR	GEOM COEF BSR	CSR	LIMITS Z1R (FT) Z2R (FT)

STATION VALUES													
	0	0	0	9	0	5							
X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAO BCOY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAO (FT)	WALL PRES (LB/SQ FT)	RETHETA						
5.1900001E-03	1.0000000E-09	0.	0.	5.93238E-05	1.86697E-02	1.67594E-02	0.						
DELTA U (FT)	DELTA C (U) (FT)	DELTA C (U2) (FT)	DELTA C (U1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA V (FT)	DELTA C (V) (FT)	DELTA C (V2) (FT)	DELTA C (V1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA W (FT)	DELTA C (W) (FT)	DELTA C (W2) (FT)	DELTA C (W1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA X (FT)	DELTA C (X) (FT)	DELTA C (X2) (FT)	DELTA C (X1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA Y (FT)	DELTA C (Y) (FT)	DELTA C (Y2) (FT)	DELTA C (Y1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA Z (FT)	DELTA C (Z) (FT)	DELTA C (Z2) (FT)	DELTA C (Z1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA A (FT)	DELTA C (A) (FT)	DELTA C (A2) (FT)	DELTA C (A1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA B (FT)	DELTA C (B) (FT)	DELTA C (B2) (FT)	DELTA C (B1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA C (FT)	DELTA C (C) (FT)	DELTA C (C2) (FT)	DELTA C (C1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA D (FT)	DELTA C (D) (FT)	DELTA C (D2) (FT)	DELTA C (D1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA E (FT)	DELTA C (E) (FT)	DELTA C (E2) (FT)	DELTA C (E1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA F (FT)	DELTA C (F) (FT)	DELTA C (F2) (FT)	DELTA C (F1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA G (FT)	DELTA C (G) (FT)	DELTA C (G2) (FT)	DELTA C (G1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA H (FT)	DELTA C (H) (FT)	DELTA C (H2) (FT)	DELTA C (H1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA I (FT)	DELTA C (I) (FT)	DELTA C (I2) (FT)	DELTA C (I1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA J (FT)	DELTA C (J) (FT)	DELTA C (J2) (FT)	DELTA C (J1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA K (FT)	DELTA C (K) (FT)	DELTA C (K2) (FT)	DELTA C (K1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA L (FT)	DELTA C (L) (FT)	DELTA C (L2) (FT)	DELTA C (L1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA M (FT)	DELTA C (M) (FT)	DELTA C (M2) (FT)	DELTA C (M1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA N (FT)	DELTA C (N) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA O (FT)	DELTA C (O) (FT)	DELTA C (O2) (FT)	DELTA C (O1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA P (FT)	DELTA C (P) (FT)	DELTA C (P2) (FT)	DELTA C (P1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA Q (FT)	DELTA C (Q) (FT)	DELTA C (Q2) (FT)	DELTA C (Q1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA R (FT)	DELTA C (R) (FT)	DELTA C (R2) (FT)	DELTA C (R1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA S (FT)	DELTA C (S) (FT)	DELTA C (S2) (FT)	DELTA C (S1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA T (FT)	DELTA C (T) (FT)	DELTA C (T2) (FT)	DELTA C (T1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA U (FT)	DELTA C (U) (FT)	DELTA C (U2) (FT)	DELTA C (U1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA V (FT)	DELTA C (V) (FT)	DELTA C (V2) (FT)	DELTA C (V1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA W (FT)	DELTA C (W) (FT)	DELTA C (W2) (FT)	DELTA C (W1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA X (FT)	DELTA C (X) (FT)	DELTA C (X2) (FT)	DELTA C (X1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03
DELTA Y (FT)	DELTA C (Y) (FT)	DELTA C (Y2) (FT)	DELTA C (Y1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (NC) (FT)	DELTA C (NO+) (FT)	DELTA C (E-) (FT)					
2.92360E-03	2.49344E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-03	2.92360E-0			

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEG K)	SMALL H (FT/SEC)	H (FT/SEC)	RHO (SLUGS/CU FT)
1	0.	0.	0.	2.13739E 03	2.64960E 07	2.64960E 07	2.52367E-05
2	5.32981E-07	4.94177E-04	2.90815E 03	2.43659E 03	3.11856E 07	5.91972E 07	1.62111E-05
3	1.06596E-06	7.37640E-04	4.06103E 03	2.66925E 03	3.56964E 07	7.21610E 07	1.49018E-05
4	1.59894E-06	9.37584E-04	4.88631E 03	2.92658E 03	4.41738E 07	8.14405E 07	1.41470E-05
5	2.13192E-06	1.11638E-03	5.52735E 03	3.04724E 03	5.19279E 07	8.86480E 07	1.36572E-05
6	2.66490E-06	1.28189E-03	6.06982E 03	3.16703E 03	5.89592E 07	9.47464E 07	1.32801E-05
7	3.19788E-06	1.43829E-03	6.49346E 03	3.29234E 03	6.52671E 07	9.95075E 07	1.30119E-05
8	3.73086E-06	1.58811E-03	6.87499E 03	3.40126E 03	7.08518E 07	1.03796E 08	1.27749E-05
9	4.26385E-06	1.73313E-03	7.14242E 03	3.49876E 03	7.57119E 07	1.06804E 08	1.26225E-05
10	4.79683E-06	1.87452E-03	7.40984E 03	3.60118E 03	7.98453E 07	1.09812E 08	1.24701E-05
11	5.32981E-06	2.01261E-03	7.66781E 03	3.71113E 03	8.32645E 07	1.12714E 08	1.23241E-05
12	5.86279E-06	2.14819E-03	7.82971E 03	3.76492E 03	8.47019E 07	1.14535E 08	1.22429E-05
13	6.39577E-06	2.28188E-03	7.99162E 03	3.80586E 03	8.57236E 07	1.16356E 08	1.21618E-05
14	6.92875E-06	2.41322E-03	8.24899E 03	3.81533E 03	8.59555E 07	1.19251E 08	1.20410E-05
15	7.46173E-06	2.54188E-03	8.48359E 03	3.81540E 03	8.59565E 07	1.21887E 08	1.19375E-05
16	7.99471E-06	2.66919E-03	8.50370E 03	3.81547E 03	8.59575E 07	1.22113E 08	1.19290E-05
17	8.52769E-06	2.79639E-03	8.50370E 03	3.81555E 03	8.59585E 07	1.22115E 08	1.19287E-05
18	9.06067E-06	2.92360E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
19	9.59365E-06	3.05081E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05
20	1.01266E-05	3.17802E-03	8.50370E 03	3.81562E 03	8.59595E 07	1.22116E 08	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)	SM H 1/2 2.64960E 07	TAUM 1/2 0.	EDEN 1/2 9.45480E 05
1	9.45480E 05	0.	0.	0.			
2	1.67702E 10	0.	0.	0.			
3	4.06286E 10	0.	0.	0.			
4	6.81601E 10	0.	0.	0.			
5	9.97687E 10	0.	0.	0.			
6	1.32403E 11	0.	0.	0.			
7	1.66215E 11	0.	0.	0.			
8	1.97416E 11	0.	0.	0.			
9	2.24618E 11	0.	0.	0.			
10	2.51106E 11	0.	0.	0.			
11	2.76203E 11	0.	0.	0.			
12	2.93947E 11	0.	0.	0.			
13	3.11431E 11	0.	0.	0.			
14	3.39468E 11	0.	0.	0.			
15	3.64925E 11	0.	0.	0.			
16	3.67093E 11	0.	0.	0.			
17	3.67084E 11	0.	0.	0.			
18	3.67074E 11	0.	0.	0.			
19	3.67074E 11	0.	0.	0.			
20	3.67074E 11	0.	0.	0.			
U 1/2	FH 1/2	RHO 1/2	T 1/2	V 1/2	SM H 1/2	TAUM 1/2	EDEN 1/2
2.07465E 03	2.64960E 07	2.52367E-C5	2.13739E 03	0.	2.64960E 07	0.	9.45480E 05
C(1) 1/2							
2.27410E-C1	6.72270E-C4	7.64582E-C1	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	

STATION VALUES									
	5	3	3	5	5				
DELTA X (FT)	DELTA X (FT)	ZETA 1 (FT)	RAD BODY (FT)	BL MASS FLOW (LB SEC/FT)	STREAMTUBE RAD (FT)	WALL PRES (LB/SQ FT)	REI METE		
5.1900058E-02	3.2000000E-08	2.7253924E-02	4.2619041E-02	5.91032E-05	1.86475E-02	1.67594E-02	2.51014E-01		
DELTA U (FT)	DELTA U (FT)	DELTA C (O2) (FT)	DELTA C (O1) (FT)	DELTA C (N2) (FT)	DELTA C (N1) (FT)	DELTA C (N0) (FT)	DELTA C (E-) (FT)	DELTA C (E-) (FT)	
2.43340E-03	2.42097E-03	2.83787E-03	2.32559E-03	2.83787E-03	2.46460E-03	2.83787E-03	2.46247E-03	2.46247E-03	
DELTA X (FT)	DELTA X (FT)	DELTA STAR (FT)	THETA (FT)	NU/SCRT (REX)	NU/SCRT (REW)	C SUB F			
2.87921E-03	8.31842E-03	7.41979E-04	4.52473E-04	7.96174E-01	4.68407E-01	2.13448E-02			
	C (O2)	C (O1)	C (N2)	C (N1)	C (N0)	C (NO+)	C (E-)	C SUM	
1	4.27410E-01	6.72270E-04	7.64570E-01	1.47020E-09	7.33560E-03	3.61750E-12	6.61368E-17	9.99988E-01	
2	1.29756E-01	6.39162E-01	7.51943E-01	2.32167E-05	3.43619E-02	9.98940E-08	1.82631E-12	10.00000E-01	
3	1.12417E-02	1.22084E-01	7.51594E-01	6.16322E-05	3.50186E-02	2.63226E-07	4.81311E-12	10.00000E-01	
4	6.83961E-02	1.45543E-01	7.52087E-01	1.11694E-04	3.38611E-02	4.65222E-07	8.50540E-12	10.00000E-01	
5	5.30918E-02	1.61685E-01	7.52752E-01	1.74786E-04	3.22960E-02	7.05384E-07	1.28961E-11	10.00000E-01	
6	4.16144E-02	1.74013E-01	7.53418E-01	2.45000E-04	3.07087E-02	9.62691E-07	1.75004E-11	10.00000E-01	
7	3.45614E-02	1.81824E-01	7.54005E-01	3.22883E-04	2.92850E-02	1.23344E-06	2.25503E-11	10.00000E-01	
8	2.86208E-02	1.88444E-01	7.54525E-01	3.98673E-04	2.80105E-02	1.49215E-06	2.72802E-11	10.00000E-01	
9	2.56918E-02	1.91834E-01	7.54863E-01	4.68790E-04	2.71403E-02	1.71826E-06	3.14140E-11	10.00000E-01	
10	2.27632E-02	1.95224E-01	7.55202E-01	5.38907E-04	2.62702E-02	1.94436E-06	3.55477E-11	10.00000E-01	
11	1.99884E-02	1.98441E-01	7.55525E-01	6.07249E-04	2.54366E-02	2.16402E-06	3.55636E-11	10.00000E-01	
12	1.87739E-02	1.99903E-01	7.55689E-01	6.57589E-04	2.49735E-02	2.31832E-06	4.43845E-11	10.00000E-01	
13	1.75596E-02	2.01365E-01	7.55854E-01	7.07932E-04	2.45104E-02	2.47262E-06	4.52055E-11	10.00000E-01	
14	1.59034E-02	2.03388E-01	7.56087E-01	7.90885E-04	2.38279E-02	2.72232E-06	4.97691E-11	10.00000E-01	
15	1.45720E-02	2.05032E-01	7.56282E-01	8.68136E-04	2.32426E-02	2.95171E-06	5.39645E-11	10.00000E-01	
16	1.44690E-02	2.05160E-01	7.56298E-01	8.74829E-04	2.31950E-02	2.97140E-06	5.43244E-11	10.00000E-01	
17	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01	
18	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01	
19	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01	
20	1.44690E-02	2.05160E-01	7.56298E-01	8.74830E-04	2.31950E-02	2.97140E-06	5.43245E-11	10.00000E-01	

K	PSI (LB SEC/FT)	Y (FT)	U (FT/SEC)	T (DEC MI)	SMALL H (FT/SEC) SQ	H (FT/SEC) SQ	RWD (SLUGS/CU FT)
1	0.	0.	0.	2.13742E 03	2.64960E 07	2.64960E C7	2.52367E-05
2	5.32981E-07	4.60655E-04	2.90815E 03	3.10402E 03	2.64960E 07	5.91971E C7	1.61649E-05
3	1.06596E-06	7.17187E-04	4.06103E 03	3.26682E 03	5.49665E 07	7.21609E C7	1.48736E-05
4	1.59894E-06	9.11330E-04	4.86630E 03	3.37858E 03	6.39150E 07	8.14404E C7	1.41207E-05
5	2.13127E-06	1.08497E-03	5.52735E 03	3.45653E 03	6.95025E 07	8.86479E C7	1.36262E-05
6	2.66490E-06	1.24565E-03	6.06961E 03	3.51598E 03	7.33722E 07	9.47464E C7	1.32663E-05
7	3.19788E-06	1.39745E-03	6.49346E 03	3.56992E 03	7.63251E 07	9.95075E C7	1.29860E-05
8	3.73066E-06	1.54285E-03	6.87499E 03	3.61251E 03	7.84249E 07	1.03796E C8	1.27666E-05
9	4.26365E-06	1.68358E-03	7.14242E 03	3.65128E 03	8.01632E 07	1.06804E C8	1.25973E-05
10	4.79663E-06	1.82086E-03	7.40944E 03	3.68494E 03	8.12971E 07	1.09812E C8	1.24491E-05
11	5.32981E-06	1.95482E-03	7.66760E 03	3.71318E 03	8.23595E 07	1.12714E C8	1.23232E-05
12	5.86279E-06	2.08625E-03	7.92571E 03	3.73501E 03	8.33165E 07	1.14535E C8	1.22370E-05
13	6.39577E-06	2.21587E-03	8.18381E 03	3.75498E 03	8.38828E 07	1.16356E C8	1.21578E-05
14	6.92875E-06	2.34320E-03	8.44191E 03	3.78647E 03	8.44229E 07	1.19251E C8	1.20373E-05
15	7.46173E-06	2.46792E-03	8.69581E 03	3.81314E 03	8.52285E 07	1.21087E C8	1.19373E-05
16	7.99471E-06	2.59130E-03	8.95370E 03	3.81542E 03	8.59014E 07	1.22113E C8	1.19290E-05
17	8.52769E-06	2.71458E-03	9.21161E 03	3.81552E 03	8.59567E 07	1.22115E C8	1.19287E-05
18	9.06067E-06	2.83787E-03	9.46951E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05
19	9.59365E-06	2.96116E-03	9.72741E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05
20	1.01266E-05	3.08444E-03	9.98531E 03	3.81562E 03	8.59595E 07	1.22116E C8	1.19284E-05

K	ELECTRON DENS PART/CC	MU L (LB SEC/SQFT)	MU T (LB SEC/SQFT)	TAUM (LB/SQFT)	SP H 1/2	TAUM 1/2	EDEN 1/2
1	5.45480E 05	1.33896E-06	0.	9.20574E 00			
2	1.67234E 10	1.63861E-06	0.	9.09546E 00			
3	4.05525E 10	1.68446E-06	0.	8.22637E 00			
4	6.80345E 10	1.71432E-06	0.	7.25588E 00			
5	9.95435E 10	1.73522E-06	0.	6.37958E 00			
6	1.32266E 11	1.75100E-06	0.	5.89173E 00			
7	1.65613E 11	1.76519E-06	0.	4.90899E 00			
8	1.97278E 11	1.77632E-06	0.	4.64848E 00			
9	2.24170E 11	1.78636E-06	0.	3.36544E 00			
10	2.50483E 11	1.79508E-06	0.	3.48491E 00			
11	2.76183E 11	1.80234E-06	0.	3.46430E 00			
12	2.99604E 11	1.80794E-06	0.	2.22375E 00			
13	3.11321E 11	1.81304E-06	0.	2.26162E 00			
14	3.29203E 11	1.82106E-06	0.	3.87329E 00			
15	3.45510E 11	1.82763E-06	0.	3.43215E 00			
16	3.67692E 11	1.82840E-06	0.	2.98029E-01			
17	3.67003E 11	1.82843E-06	0.	1.08626E-05			
18	3.67073E 11	1.82845E-06	0.	1.81041E-06			
19	3.67073E 11	1.82845E-06	0.	0.			
20	3.67073E 11	1.82845E-06	0.	0.			
U 1/2	FM 1/2	RHO 1/2	Y 1/2	Y 1/2	SP H 1/2	TAUM 1/2	EDEN 1/2
2.07405E 03	4.98306E 07	1.76318E-05	2.90841E 03	3.29699E-04	4.76785E 07	9.09546E 00	5.02542E 09
C(1) 1/2							
1.57656E-01	5.82456E-02	7.53913E-01	6.23856E-06	3.01770E-02	2.75210E-08	5.03152E-13	

"STREAMLINE OUTPUT"

SHOCK ANGLE= XDO	1.24687E 00 #100	PRDS= U	6.12958E 02 C(N)	2.12017E-03 C(M)	DIN2= C(MO+)	1.88198E-02 C(E-)	UDS= C(E-)	4.81725E 03 Y	RHO	ME
2.32831E-19	2.12017E-03	4.81725E 03	7.37997E-20	0.	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.49246E-19	2.12017E-03	4.81725E 03	1.10700E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.07454E-19	2.12017E-03	4.81725E 03	1.29149E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.65661E-19	2.12017E-03	4.81725E 03	1.47599E-19	6.97570E-35	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.28057E-18	2.12017E-03	4.81725E 03	4.05898E-19	1.83112E-33	0.	0.	0.	8.23679E 03	2.39659E-05	0.
2.44472E-18	2.12017E-03	4.81725E 03	7.74897E-19	7.20241E-33	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.77303E-18	2.12017E-03	4.81725E 03	1.51289E-18	7.99008E-32	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.03610E-17	2.12017E-03	4.81725E 03	3.28409E-18	1.32903E-31	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.96742E-17	2.12017E-03	4.81725E 03	6.23607E-18	4.79457E-31	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.83006E-17	2.12017E-03	4.81725E 03	2.63096E-17	8.54337E-30	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.30041E-17	2.12017E-03	4.81725E 03	4.99255E-17	3.07451E-29	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.57510E-16	2.12017E-03	4.81725E 03	9.71574E-17	1.62931E-28	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.06522E-16	2.12017E-03	4.81725E 03	2.10514E-16	5.46888E-28	0.	0.	0.	8.23679E 03	2.39659E-05	0.
6.64149E-16	2.12017E-03	4.81725E 03	3.99441E-16	1.96808E-27	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.26020E-15	2.12017E-03	4.81725E 03	7.77296E-16	7.44350E-27	0.	0.	0.	8.23679E 03	2.39659E-05	0.
2.45229E-15	2.12017E-03	4.81725E 03	1.68415E-15	3.50808E-26	0.	0.	0.	8.23679E 03	2.39659E-05	0.
5.31331E-15	2.12017E-03	4.81725E 03	3.19557E-15	1.59460E-25	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.00817E-14	2.12017E-03	4.81725E 03	6.21842E-15	4.76390E-25	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.96184E-14	2.12017E-03	4.81725E 03	2.40581E-14	8.06148E-24	0.	0.	0.	8.23679E 03	2.39659E-05	0.
4.25066E-14	2.12017E-03	4.81725E 03	2.53647E-14	3.04891E-23	0.	0.	0.	8.23679E 03	2.39659E-05	0.
8.06535E-14	2.12017E-03	4.81725E 03	4.97475E-14	1.43398E-22	0.	0.	0.	8.23679E 03	2.39659E-05	0.
1.56948E-13	2.12017E-03	4.81725E 03	2.07786E-13	5.15931E-21	0.	0.	0.	8.23679E 03	2.39659E-05	0.
3.40053E-13	2.12017E-03	4.81725E 03	2.50451E-13	9.17747E-21	0.	0.	0.	8.23679E 03	2.39659E-05	0.
6.45229E-13	2.12017E-03	4.81725E 03	3.97981E-13	1.03320E-19	6.23059E-33	0.	0.	8.23679E 03	2.39659E-05	0.
1.25558E-12	2.12017E-03	4.81725E 03	8.62294E-13	4.01703E-19	3.82647E-33	0.	0.	8.23679E 03	2.39659E-05	0.
2.72042E-12	2.12017E-03	4.81725E 03	2.87432E-12	1.58261E-18	2.58111E-32	0.	0.	8.23679E 03	2.39659E-05	0.
9.06808E-12	2.12017E-03	4.81725E 03	5.66020E-12	6.28101E-18	2.17999E-31	0.	0.	8.23679E 03	2.39659E-05	0.
1.78571E-11	2.12017E-03	4.81725E 03	1.13230E-11	2.50242E-17	1.78365E-30	0.	0.	8.23679E 03	2.39659E-05	0.
3.54353E-11	2.12017E-03	4.81725E 03	2.23756E-11	1.13744E-16	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
7.05915E-11	2.12017E-03	4.81725E 03	9.41900E-11	3.77358E-16	1.15986E-28	0.	0.	8.23679E 03	2.39659E-05	0.
1.40904E-10	2.12017E-03	4.81725E 03	1.73434E-10	1.43248E-27	9.30325E-28	0.	0.	8.23679E 03	2.39659E-05	0.
5.47154E-10	2.12017E-03	4.81725E 03	3.51732E-10	5.51458E-15	7.45237E-27	0.	0.	8.23679E 03	2.39659E-05	0.
1.10965E-09	2.12017E-03	4.81725E 03	7.08330E-10	1.55145E-15	5.96583E-26	0.	0.	8.23679E 03	2.39659E-05	0.
2.34655E-09	2.12017E-03	4.81725E 03	1.70833E-09	6.29237E-15	3.82008E-24	0.	0.	8.23679E 03	2.39659E-05	0.
4.48465E-09	2.12017E-03	4.81725E 03	1.42153E-09	2.53449E-14	3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
8.98465E-09	2.12017E-03	4.81725E 03	2.84793E-09	1.01733E-13	3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
1.79846E-08	2.12017E-03	4.81725E 03	5.70075E-09	4.07640E-12	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
3.59846E-08	2.12017E-03	4.81725E 03	1.40658E-08	1.63198E-12	1.15986E-28	0.	0.	8.23679E 03	2.39659E-05	0.
7.19846E-08	2.12017E-03	4.81725E 03	2.28181E-08	6.43078E-12	9.30325E-28	0.	0.	8.23679E 03	2.39659E-05	0.
1.43985E-07	2.12017E-03	4.81726E 03	4.56424E-08	1.04286E-11	7.45237E-27	0.	0.	8.23679E 03	2.39659E-05	0.
2.79855E-07	2.12017E-03	4.81727E 03	9.12944E-08	1.04525E-10	5.96583E-26	0.	0.	8.23679E 03	2.39659E-05	0.
5.75985E-07	2.12017E-03	4.81731E 03	1.82613E-07	4.18114E-10	3.82008E-24	0.	0.	8.23679E 03	2.39659E-05	0.
1.15198E-06	2.12017E-03	4.81737E 03	3.65305E-07	1.67243E-09	3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
2.30398E-06	2.12017E-03	4.81750E 03	7.30912E-07	6.68925E-08	2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
4.60798E-06	2.12017E-03	4.81755E 03	1.46302E-06	2.75261E-08	1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
9.21598E-06	2.12017E-03	4.81826E 03	2.93076E-06	1.06974E-07	1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
1.84320E-05	2.12017E-03	4.81928E 03	5.88018E-06	4.27597E-07	1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
3.68640E-05	2.12017E-03	4.82133E 03	1.18334E-05	1.70797E-06	1.00266E-18	0.	0.	8.23679E 03	2.39659E-05	0.
7.37280E-05	2.12017E-03	4.82541E 03	2.13946E-05	6.81403E-06	8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
1.47456E-04	2.2768E-03	4.83358E 03	4.89197E-05	2.70816E-05	6.43348E-17	0.	0.	8.23679E 03	2.39659E-05	0.
2.94912E-04	2.3352E-03	4.84988E 03	1.01278E-04	1.06893E-04	3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
5.57036E-04	2.5635E-03	4.87876E 03	1.99472E-04	3.71115E-04	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
1.08134E-03	2.90864E-03	4.93614E 03	4.01841E-04	1.31493E-03	1.15986E-28	0.	0.	8.23679E 03	2.39659E-05	0.
1.99885E-03	3.57766E-03	5.03548E 03	7.38032E-04	3.98423E-03	9.30325E-28	0.	0.	8.23679E 03	2.39659E-05	0.
3.30957E-03	4.53340E-03	5.17537E 03	1.14503E-03	9.12567E-03	1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
5.40672E-03	6.0258E-03	5.39566E 03	1.63219E-03	1.84331E-02	1.98865E-07	0.	0.	8.23679E 03	2.39659E-05	0.
8.55245E-03	8.33634E-03	5.72225E 03	2.09343E-03	3.15757E-02	1.06534E-11	0.	0.	8.23679E 03	2.39659E-05	0.
					2.44435E-11	0.	0.	8.23679E 03	2.39659E-05	0.
					6.92053E-35	0.	0.	8.23679E 03	2.39659E-05	0.
					3.82647E-33	0.	0.	8.23679E 03	2.39659E-05	0.
					2.58111E-32	0.	0.	8.23679E 03	2.39659E-05	0.
					2.17999E-31	0.	0.	8.23679E 03	2.39659E-05	0.
					1.78365E-30	0.	0.	8.23679E 03	2.39659E-05	0.
					1.44222E-29	0.	0.	8.23679E 03	2.39659E-05	0.
					7.45237E-27	0.	0.	8.23679E 03	2.39659E-05	0.
					5.96583E-26	0.	0.	8.23679E 03	2.39659E-05	0.
					3.82008E-24	0.	0.	8.23679E 03	2.39659E-05	0.
					3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
					2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
					1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
					1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
					1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
					1.00266E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					6.43348E-17	0.	0.	8.23679E 03	2.39659E-05	0.
					3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
					2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
					1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
					1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
					1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
					1.00266E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					6.43348E-17	0.	0.	8.23679E 03	2.39659E-05	0.
					3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
					2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
					1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
					1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
					1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
					1.00266E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					6.43348E-17	0.	0.	8.23679E 03	2.39659E-05	0.
					3.05637E-23	0.	0.	8.23679E 03	2.39659E-05	0.
					2.44529E-22	0.	0.	8.23679E 03	2.39659E-05	0.
					1.95642E-21	0.	0.	8.23679E 03	2.39659E-05	0.
					1.56537E-20	0.	0.	8.23679E 03	2.39659E-05	0.
					1.25266E-19	0.	0.	8.23679E 03	2.39659E-05	0.
					1.00266E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					8.02910E-18	0.	0.	8.23679E 03	2.39659E-05	0.
					6.43348E-17	0.	0			